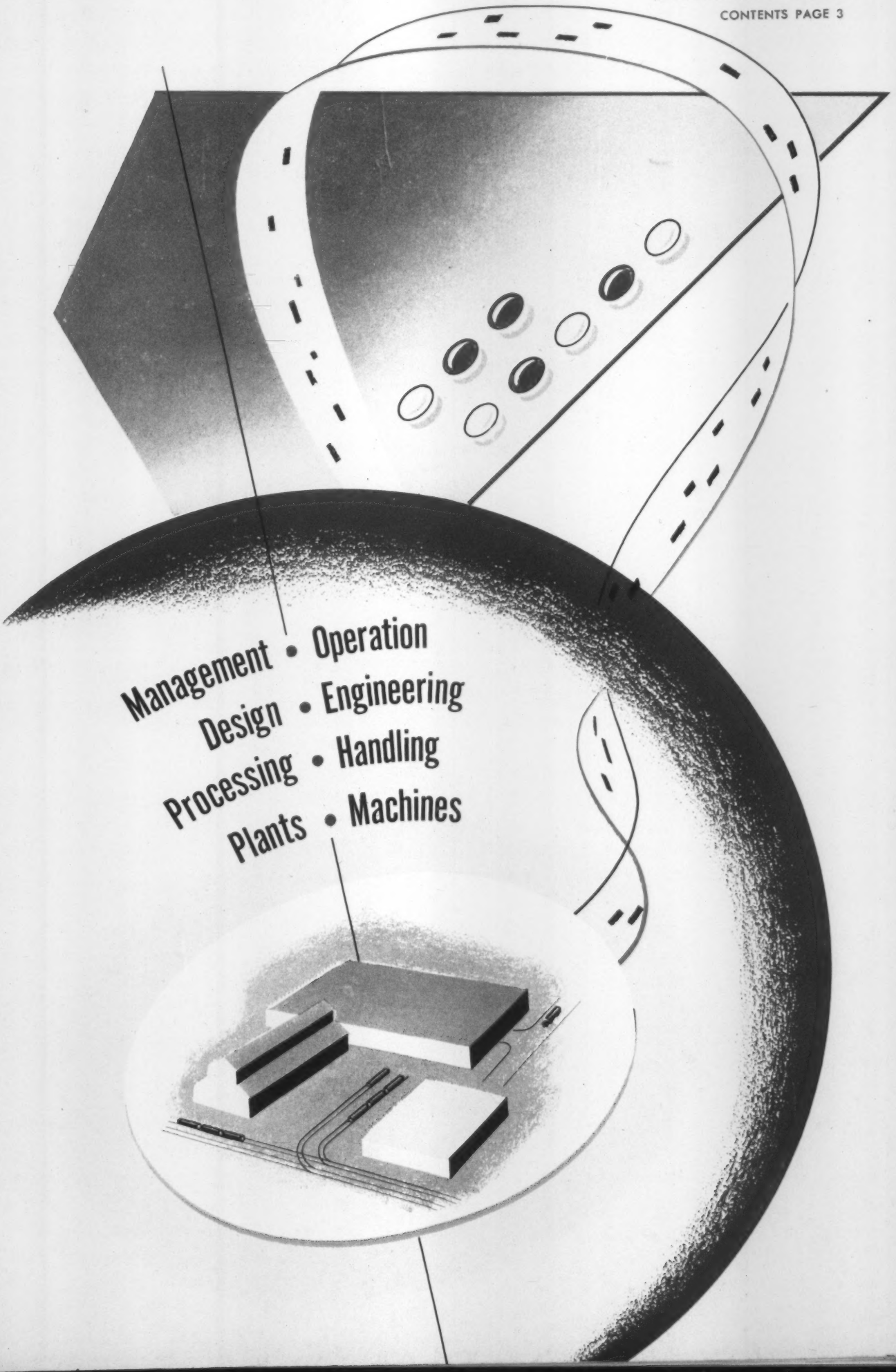
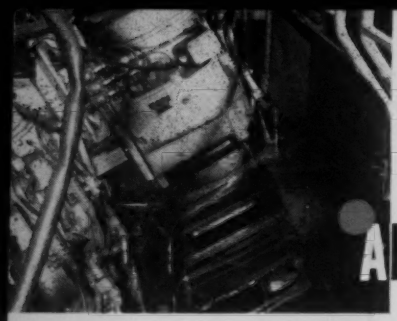
AUTOMATION

NOVEMBER 1954
A PENTON PUBLICATION
CONTENTS PAGE 3





AMAZING "AUTOMATED" DRILL-GRINDER TEAM

DOES THE JOB 22 TIMES FASTER

Machining mounting surfaces on the underside of huge tank hulls required ten separate horizontal boring mill setups. Handling, positioning and working on the heavy, unwieldy hulls created a serious bottleneck in production.

Relying on Wean Equipment's reputation as a leading designer and builder of special machinery for industry this concern gave Wean the green light. Wean Equipment engineers set to work and came up with the first completely automatic adaption of a bank of grinding heads to work on an angular surface.

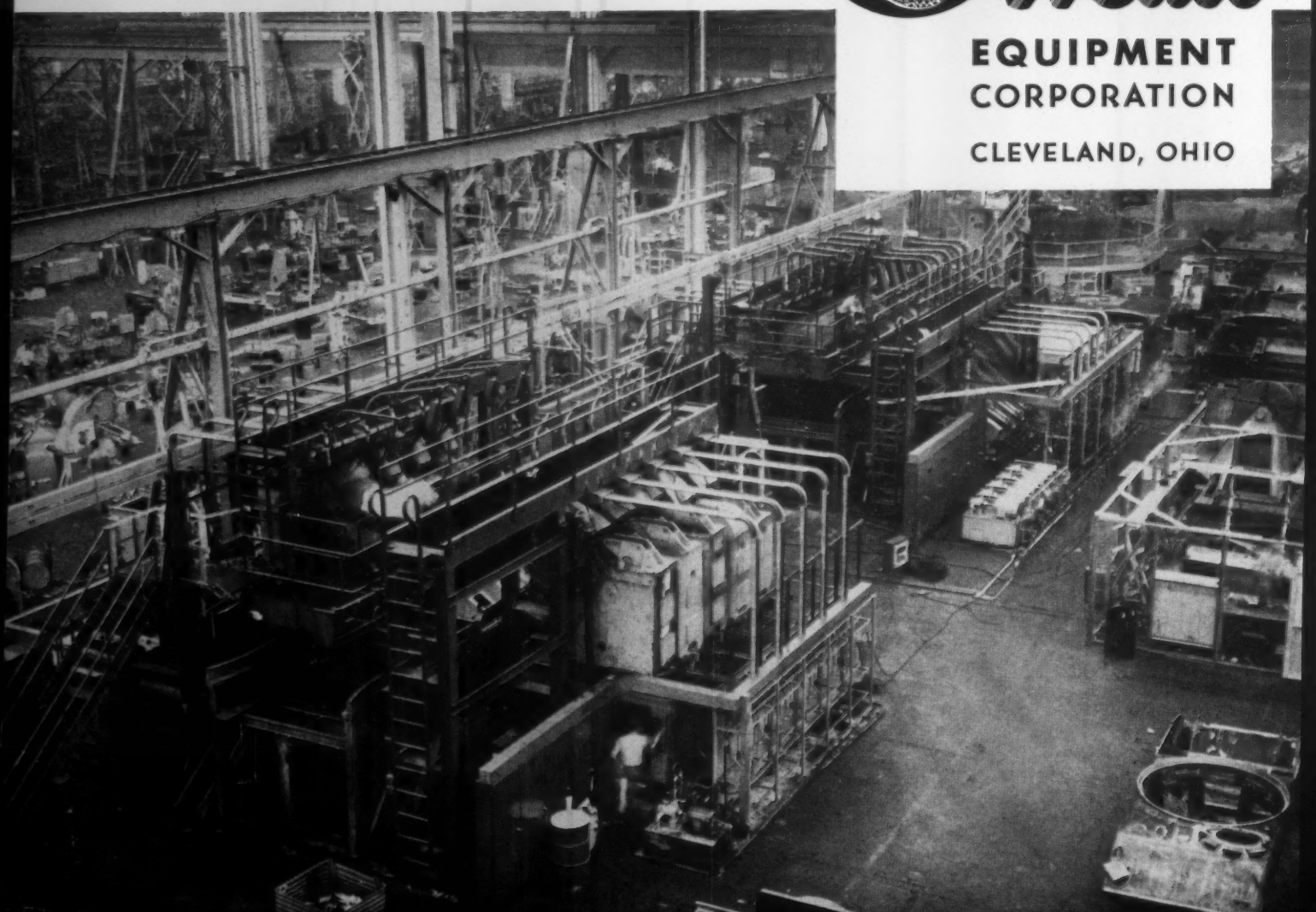
The machine grinds all surfaces simultaneously with unmatched precision, and completes its job 22 times faster than the old method. According to company officials the machine paid for itself in short order by increasing production, eliminating reworking created by human error, and releasing boring mills to other production work. Result: A second machine to perform a difficult drilling operation on the same hull was ordered from Wean. These are typical examples of Wean Equipment's ability to develop and build practical automation equipment.

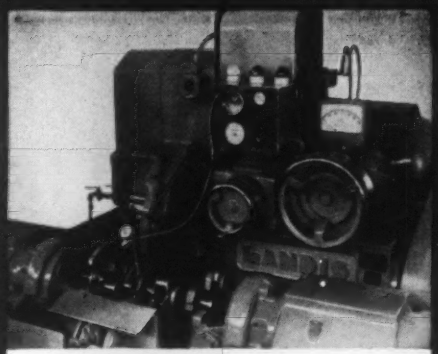
If you have a production problem — why not call on Wean Equipment and get results.

Wean

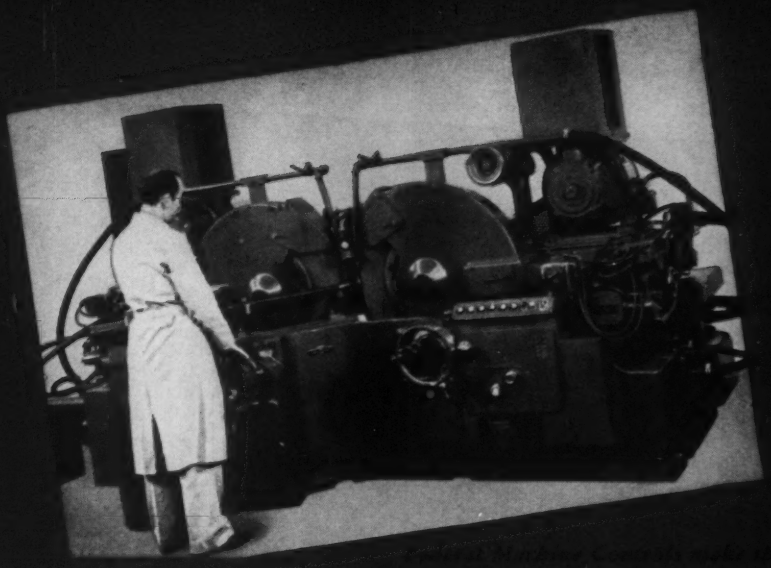
EQUIPMENT
CORPORATION

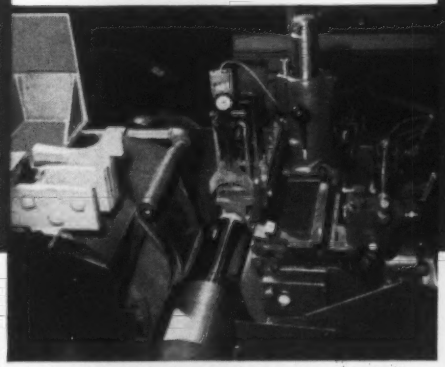
CLEVELAND, OHIO



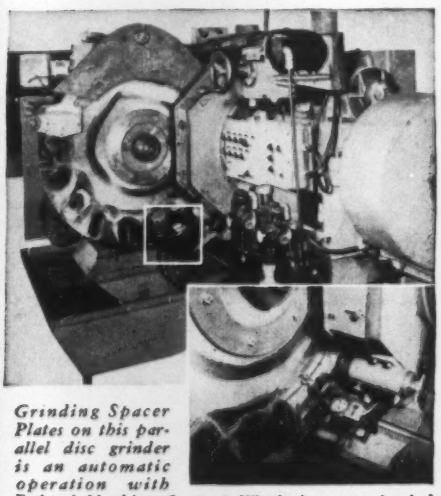


Grinding Main Journals on a Crankshaft is done quickly and without scrap with this Federal Air-Electric Grinding Gage. The operator loads the machine, snaps the caliper on the work and starts the machine cycle. When the work is down to size, the wheel automatically backs up. The large Air Dial and the three signal lights provide visual checks on the progress of the grinding. With this Machine Control Gage it is impossible to grind undersize scrap because the gage automatically backs the wheel up when work is to size.





This Federal unit, employing an Arnold continuous caliper type grinding gage, automatically controls the size of the journal surfaces of 1100 lb. freight car axles. The gage, ordinarily retracted to provide loading clearance, automatically springs onto the work and takes control of the grinding process at the start of the grinding cycle. Signal lights tell the operator when work is "over size", "near size", or "to size" and are connected electronically to the machine controls so the grinding cycle is automatically stopped when the required size is obtained. Tolerances are consistently maintained well within the plus 0.0005", minus 0.0000" specified.



Grinding Spacer Plates on this parallel disc grinder is an automatic operation with Federal Machine Control. Workpieces are loaded in the slotted carrier wheel and the gage controls the feed of the wheels to compensate for wheel wear. Corrections are made alternately to each wheel-head to maintain the centering of the carrier wheel. Automatic controls assure continuous production of good pieces, eliminating scrap.

A few of many applications

FEDERAL *Automatic* MACHINE CONTROL GAGES

have established their efficiency

AUTOMATION is a new term applied to an idea that general machinery manufacturers have been doing ever since Eli Whitney invented his Cotton Gin. But, controlling Machine Tools automatically so that they produce work to required sizes is comparatively new.

Federal, however, has been designing and building Gages for this purpose for several years. We offer this tried and proven experience to all builders and users of machinery where Automatic Dimensional Control of Machine Tools is desired. We can handle all phases of the work; from work-handling through gaging, machine control and disposal.

Federal is ready to provide standardized package units for air, electrical, electronic or combination controls and **will cooperate with your engineers to adapt these to your machine requirements.** Call —

FEDERAL PRODUCTS CORPORATION
43911 EDDY STREET • PROVIDENCE 1, RHODE ISLAND

See us at Booth 719 at the FIRST INTERNATIONAL AUTOMATION EXPOSITION Nov. 29—Dec. 2, 1954 at the 244th Regiment Armory, N.Y.C.

SOME OF MANY POSSIBILITIES

Percentage reject control. A simulation of automatic statistical Q.C.

Automatic shut-off when dimension out-of-control.

Automatic tool adjustment or compensation.

Tool Adjustment Signalling.

Automatic classification according to dimension.

Automatic line operation signals, etc., etc.

Ask **FEDERAL**
FOR ANYTHING IN MODERN GAGES...

How WESTINGHOUSE *saves $37,000 yearly* at its Trafford, Pa. Foundry

■ This plant formerly loaded and unloaded bagged material, handled barrels and stored patterns by manual methods. Today fork trucks have mechanized all these operations. Result: *an annual saving of $37,000.*

In the warehouse, for example, the fork trucks now stack materials on pallets—right up to the rafters. Indirect benefits: space saving, fewer accidents, less material damage. Direct benefits: substantial savings in labor costs.

Fork-truck handling and tiering of patterns eliminated back-breaking work, increased storage capacity 500% and made additional labor savings.

Unloading bagged material (wood flour, sea coal, mogal, pich, etc.) and fire brick (formerly man-handled one at a time) is now done in palletized unit loads—another big cost saver. And still more money is saved by handling barrels with a Baker 4-Purpose Carriage truck and drum shoes.

Write for 6-page special report on the application of Baker attachments to various loads. The Baker-Raulang Co., 1202 W. 80th Street, Cleveland 2, Ohio.

Baker®
industrial trucks

NOVEMBER, 1954
Vol. 1—No. 4

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATION

EDITORIAL STAFF

ROGER W. BOLZ, Editor
JAMES C. KEEBLER, Associate Editor
WILBUR R. ELLIS, Assistant Editor
STANLEY B. STEWART, Assistant Editor
PATRICIA M. HUFFERD, Assistant Editor
FLEUR E. WOODS, Assistant Editor
WILLIAM G. KELLOGG, Art Director

REGULAR DEPARTMENTS

Automation Outlook, 4
Automation News, 8
New Equipment, 67
New Components, 78
Patents, 92
New Literature, 97
Abstracts, 104
Editorial Index, 114
New Books, 116

No Robots Here, 17
EDITORIAL—adherence to fact and eliminating the sensational finds automation an engineering development.

Design For Manufacture, 18
ROGER W. BOLZ—design for mass interchangeable manufacture is stepping stone to design for automation.

High Speed Printing, 22
NEW DEVELOPMENT—output device for electronic computer forms letters by moving wires in matrix.

Applying Bottle Seals, 23
AUTOMATION TODAY—machine for packaging line applies cellulose seal around neck of bottle.

Pneumatic Time Delay, 28
ELECTRICAL CONTROL—device operates auxiliary protective circuit after main operating cycle has stopped.

Latex To Foam Rubber, 31
LEONARD J. BISHOP—raw material to finished products in a plant designed for automatic production.

Continuous Weighing Of Solids, 39
ROBERT H. BERG—measurements on belt conveyors or in bins and hoppers provide quantitative control.

Pneumatic Control For Paint Spraying, 44
DONALD J. PEEPS—readily available compressed air utilized to signal guns in material conserving system.

Industrial Process Stream Analysis, 46
MASS SPECTROMETER—instrument monitors chemical composition of product without laboratory testing.

Engineering Automatic Systems, 47
PHILIP R. MARVIN—management study of programming and planning required to get results with automation.

Hydraulic And Pneumatic Servos, 49
R. HADEKEL—part two—develops methods of improving servo performance to achieve desired characteristics.

Automatic Control Terminology, 59
CHARACTERISTICS OF AUTOMATIC CONTROL—standard process control terms defined and illustrated.

Electronic Servo Positioning, 61
WALTON RAINEY—system for indexing machine tool element provides accuracy and saves operator time.

AUTOMATION OUTLOOK

NO SIMPLE SOLUTION

". . . a machine built for manufacturing foam rubber mattresses starts with liquid latex, performs each operation successively and automatically with only 24 operators. It runs 24 hours a day and six days a week, requiring almost no service. However, you don't build a machine like this overnight. You need a lot of experience, and you have to be sure you build quality into it. Otherwise the customer will lose in maintenance costs what he gains in efficiency. . ."—*L. J. Bishop, Mechanical Handling Systems, Inc.* *See page 31.*

DODGING THE ROCKS

". . . the hand operator has advantages over the mechanical controller. He can think, judge, anticipate. There is advantage in being able to act with reason. Control instruments on the other hand, have the advantages of stability, reliability and speed. An automatic pilot keeps a boat on course more accurately than the best helmsman, but it will not dodge around a rock. A modern controller, pneumatic or electric, will hold a process much closer to a control point than any operator, but if an upset is serious enough we go back to hand control. . ."—*R. A. Bristol, treasurer, Foxboro Co.*

COMPROMISE, THE ANSWER

". . . it is usually better to settle for something less than a 100 per cent automatic process rather than overcomplicate a system or delay its development in an attempt to handle all conceivable operations. Initially, many equipment designs may not be readily adaptable to a completely automatic process . . ."—*Ben Warriner, advanced electronics center, General Electric Co.*

SOME DESIRABLE RESULTS

". . . I am not one who believes that one day everything will be produced in an automatic factory without any labor force. Automation must either make possible some desirable result that could not be accomplished in any other way or it must accomplish its task at a net saving in cost. There will always be many places where highly automatic processes will never make engineering or economic sense . . ."—*Henry F. Dever, president, Brown Instruments Div., Minneapolis-Honeywell Regulator Co.*

NO "THINKING" HERE

". . . among the most important features of a properly planned and efficiently operated automatic factory are not only such benefits as lower costs and higher production rates but far greater stability in product quality and increased flexibility. You will note I said properly planned and operated, since an automatic factory is only as good as the human brains which conceived it and run it. No electronic brain, no matter how marvelously intricate and precise, can *think;* it can do only what a human brain wants it to do. The automatic factory, therefore, will not be a panacea for production ills, but will make even more effective an already effective organization . . ."—*Don G. Mitchell, chairman of the board, Sylvania Electric Products Inc.*

POCKETBOOK IMPACT

". . . to grasp the impact of automatic controls upon our economy we must realize that with such control equipment, efficient and economic production would be impossible in many industries. To match today's petroleum refining output using manually operated equipment, would require four times as much crude oil and cost five times as much . . ."—*W. A. Wildhack, chief instrument engineer, National Bureau of Standards.*

AUTOMATION

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

EDWARD S. LAWSON
Business Manager

J. M. Castiglione, *Production Manager*

George J. Auner, *Statistician*

Lois Gartman, *Staff Assistant*

Advertising Representatives

New York 17 ..... 60 East 42nd St.
Robert G. Macbeth
Murray Hill 2-2581

Cleveland 13 ..... Penton Building
Larry D. Brennan
Gordon W. Rosencrans, Jr.
Main 1-8260

Chicago 11 ..... 520 North Michigan Ave.
Richard K. Lotz
Richard W. Jones
Whitehall 4-1234

Los Angeles 57 ..... 2330 West Third St.
The Robert W. Walker Co.
Dunkirk 7-4388

San Francisco 4 ..... 57 Post St.
The Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. ..... 331 South Twelfth St.
Fred J. Allen
Griffin 7854

Circulation

Jack C. Gernhard, *Manager*

Amy Lombardo, *Directory & List Dept.*

Published by

THE PENTON PUBLISHING COMPANY

G. O. HAYS ..... *President and Treasurer*
R. C. JAENKE ..... *Executive Vice President*
F. G. STEINEBACH ..... *Vice Pres. and Secretary*
F. O. RICE ..... *Vice President*
J. P. LIPKA ..... *Asst. Secy. and Asst. Treas.*

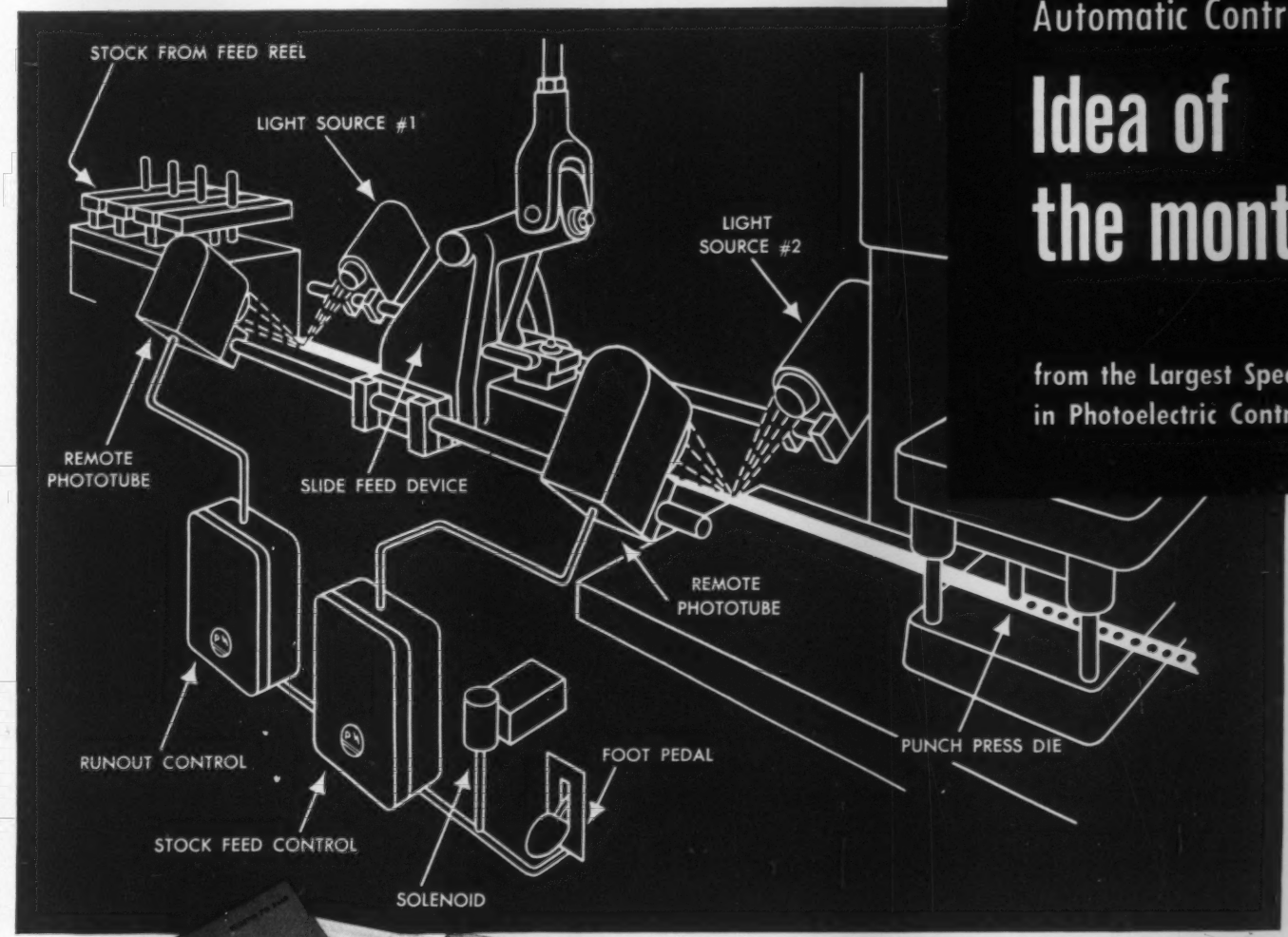
Also Publisher of
STEEL • FOUNDRY • MACHINE DESIGN
NEW EQUIPMENT DIGEST

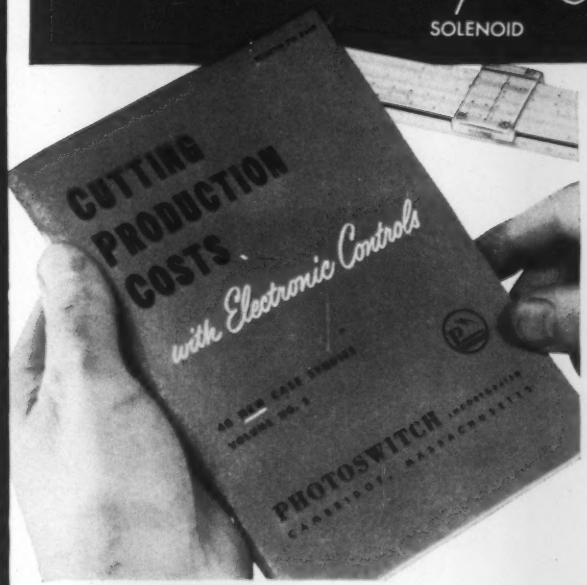
Published monthly. Subscription in the United States, possessions, and Canada: One year $10. Single copies, $1.00. Other countries one year, $20. **Copyright 1954 by The Penton Publishing Company.** **Acceptance under Section 34.64 P. L. & R. authorized.**

Automatic Control

Idea of the month...

from the Largest Specialists in Photoelectric Controls





Photoelectrically Controlled Punch Press

Problem: To protect dies from damage caused when buckled or twisted stock feeds into a 120 stroke per minute, 35 ton punch press.

Solution: At a critical point, a Photoswitch phototube and light source combination was mounted at opposite sides of the feed line. Light source is focused so that light is reflected onto phototube from the surface of properly aligned stock. If stock buckles, light beam is reflected away from phototube and control shuts down press instantly. A similar set is used to shut down press when stock runs out.

Result: Die damage completely eliminated. Full-time press attendant released for more productive work.

This Control design is typical of thousands of successful Photoswitch Systems for Automatic Electronic Control of Machinery and Processes. In Photoswitch's wide variety of "ready-to-use" photoelectric controls, liquid level controls and electronic timers, you will find controls that meet your requirements exactly. So . . . for the best solution to your control problems, call on *Photoswitch . . . first!*

FREE — 46 more ideas — Get this 76 page book. Shows in detail how designers of machines for many different industries have employed standard packaged electronic controls. Tells how they found new opportunities to reduce costs through simplification of design . . . how they developed order-getting user advantages. Gives you many idea-stimulating application studies.

SEND FOR YOUR COPY NOW ▶

Photoswitch DIVISION
ELECTRONICS CORPORATION OF AMERICA
Dept. P21-11, 77 Broadway, Cambridge 42, Mass.

Send FREE copy of "Cutting Production Costs with Electronic Controls"

Name and Title .....

Company .....

Address .....

City ..... State .....

THE DEVELOPMENT OF THE IMPACTER REPRESENTS A RADICALLY NEW CONCEPT OF THE FORGING PROCESS, WHICH, FOR THE FIRST TIME IN HISTORY, WILL MAKE AUTOMATION POSSIBLE IN THE FORGE SHOP AND FORGING POSSIBLE IN THE PRODUCTION LINE —*from "METALWORKING TOMORROW"*

FOR the first time in industrial history the automatic mass production of die forgings is now possible. Embodying the basic operation common to the forge shop, the Cecomatic Process unites them into a continuous, self-regulating forging process free from manual skills. Material flows from operation to operation and is converted from stock lengths to completed forging without being touched or handled by human hands. Yet, the process affords sufficient flexibility to permit a variety of similar forgings to be made in the same installation with no extraordinary changes in tooling.

Basic to the process is the Chambersburg IMPACTER, a radically new, revolutionary type of hammer. It uses the high-velocity impact of horizontally opposed rams to strike the forging stock simultaneously from both sides. Energy is almost completely absorbed in the forging and the impellers of the machine itself. There is no shock or vibration typical of conventional forging equipment. No massive foundations are required. IMPACTERS capable of producing forgings weighing from a few ounces to those weighing hundreds of pounds are available.

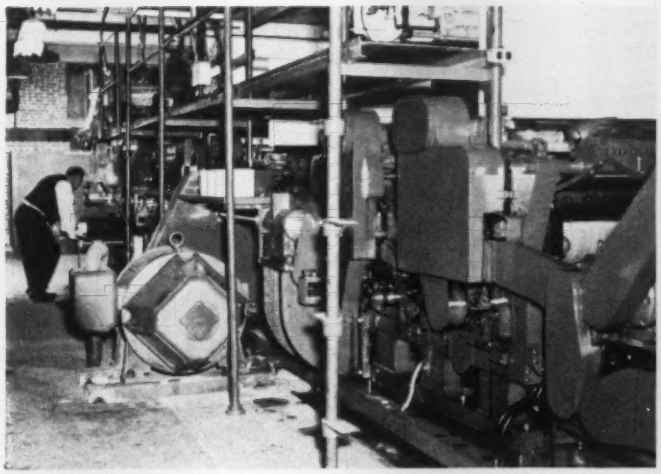
The Cecomatic Process fits into your plans for tomorrow's automated production.

CHAMBERSBURG ENGINEERING COMPANY • CHAMBERSBURG • PENNSYLVANIA

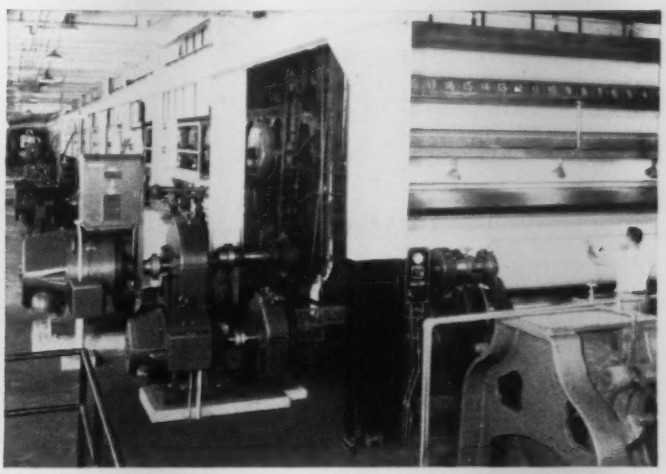
BUILT AND APPLIED BY RELIANCE

THE Tools of Automation

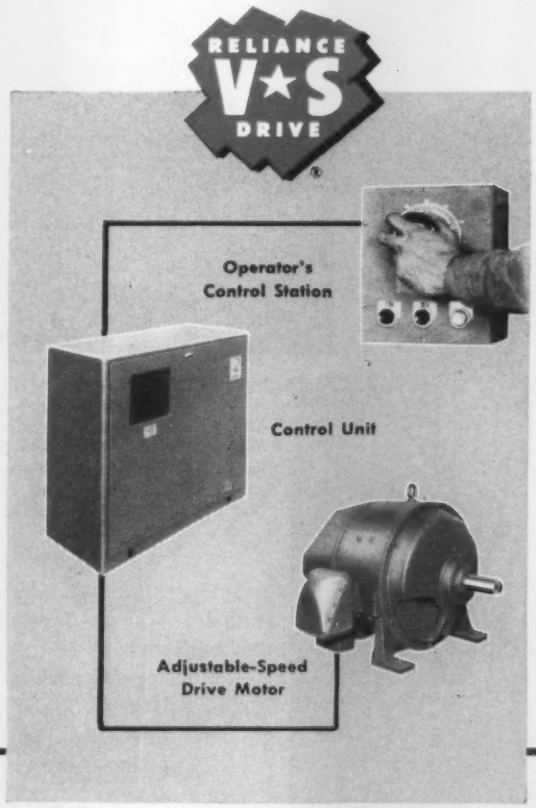
INCREASE PROFITS IN EVERY INDUSTRY



Materials in web form—paper, metal foils, synthetic sheets—become useful as they are impregnated, combined with each other, printed, and made into packages. Reliance V★S Drives power, synchronize and control all functions required for automatic operation.



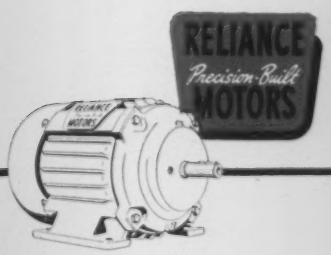
On a high-speed newsprint machine, the Reliance V★S Drive system provides unsurpassed accuracy and dependability, maintaining precise speed relationships and correct draw adjustments between all sections.



Greater machinery output . . . improved production efficiency . . . both result in increased profits. And both result from using the Tools of Automation: Reliance electric motors, adjustable-speed drives, electronic controls, and applied engineering. They're setting new standards for low cost production in *every* industry.

These Tools of Automation can most efficiently lower your costs, because they're designed and applied to *your* specific situation. Reliance Application Engineers are backed by nearly 50 years' experience in perfecting the drive systems that can help you attain the degree of automatic production you require. For further information, write for the new booklet, "The Tools of Automation".

A-1487-B



RELIANCE ELECTRIC AND ENGINEERING CO.

Sales Representatives in Principal Cities • 1038 Ivanhoe Road, Cleveland 10, Ohio

AUTOMATION NEWS

Today's events and developments of importance in the field of modern automation

Automation Advocate Honored

DURING the annual convention of the Pressed Metal Institute, **D. S. Harder,** vice president-manufacturing, Ford Motor Co. became the first recipient of an annual Presteel Award — sponsored by the institute and Worcester Pressed Steel Co.

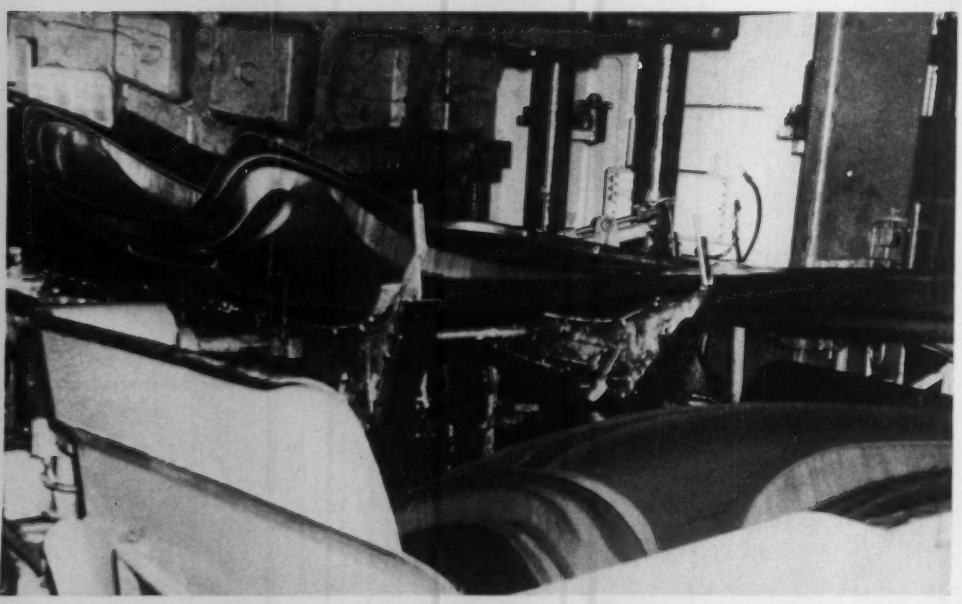
Carter C. Higgins, president and general manager of Worcester Pressed Steel, explained it was given Harder "for his contributions to enlarging the field of metal stamping through automation, through encouraging employee-training to provide more men skilled in pressing metal and through openly sharing his ideas with the industry."

The word "automation" used in the award presentation is one Harder is credited with originating while employed by General Motors Corp., to describe a system for the automatic handling of parts between progressive production processes. Since his early work with automated manufacturing this development has started what many call "the second industrial revolution."

Automation's first outstanding success occurred when it was applied as a means of loading and unloading stamping presses in the Ford-Dearborn stamping plant, where "Iron Hands" and other mechanical lifting and turn-over devices for steel sheets were installed. This and other early successes led Ford to design a complete plant around automation concept. This was the Buffalo Stamping Plant, which went into operation in September, 1950, under Harder's supervision. Other automated Ford facilities, especially its engine manufacturing operations in the Ford-Brookpark (Ohio) plant, have become symbols of automation to industry and the public at large.

The Presteel Award is presented on the basis of judging done by an awards committee including rep-

VICE PRESIDENT manufacturing, *D. S. Harder* is the first recipient of an annual Presteel Award sponsored by the Pressed Metal Institute and Worcester Pressed Steel Co. Mr. Harder is the staff executive directing all Ford Motor Co. manufacturing and production.



TYPICAL AUTOMATIC installation in a Ford Co. plant. Roof panel is removed completely from die and rests in a turnover cradle. Device in center rear is ready to remove next piece in cycle of operation. Completely inverted panel is also visible.

resentatives of: the Pressed Metal Institute; editors of leading business publications; a representative of the American Society of Tool Engineers; and a leading steel-producing company executive. Criteria considered by the committee include: notable advances in developing and marketing products using stampings; contributions in original research, or cost saving, or technical improvements made available to the industry; public education activities; company growth trends, when applicable; participation in formal education, training of new engineers, etc.; other accomplishments stimulating wider use of stampings.

Silicon Transistors

SILICON, next to oxygen the earth's most common element, long has been known to possess superior temperature stability and power handling characteristics. Until recently, difficulties of purifying, "growing" a single crystal, and fabricating silicon transistors have kept these units, laboratory devices, unproducible on a production-line basis.

For several years, electronics firms have been manufacturing tiny transistors made from germanium, a rare and expensive but more easily worked material.

Manufacture of silicon transistors, produced by Texas Instruments Inc., put laboratory techniques on a production-line basis. Initially, the semiconductor material must be purified to less than one part impurity in one billion. Then a single large perfect crystal must be grown at high temperature in an

New Data-Reduction System

SIGNIFICANT ADDITION to naval efficiency is the ALWAC electronic digital computer (AUTOMATION — *Aug. Issue*) installed at U. S. Navy's David Taylor Model Basin, Washington, D. C. Physical location of new unit is the Transonic Div. of Aerodynamics Laboratory where transonic wind tunnel testing of naval aircraft and guided missiles will be conducted under sponsorship of the Bureau of Aeronautics. New assembly will serve as computer portion of a rapid data-reduction system which measures, stores, plots and records pressures and forces of the model being tested.

Complete installation includes a data reduction system consisting of potentiometers and devices for measuring, indicating, recording and punching in coded paper tape—strain gage, balance forces and moments, and tunnel temperature. In addition, a film reading device is provided to read, record and punch on paper tape the fluid heights of photographed manometer data.

System is tied together through common input-output medium on punched tape; Flexowriter is used for manual output-input. The Navy has also found it useful to add an oscilloscope for visual tracing of various register contents.

Wind tunnel to be used is a single-return type with 7 by 10 foot throat. Powered with 27,600 hp, it is designed to operate at transonic speeds.

Machine features a large capacity rotating drum memory of 2,048 words (main storage) which stores numbers and instructions used by the unit to perform its computations. Drum is composed of a cylinder rotating about its longitudinal axis, with a number of reading and writing heads mounted in near-contact with surface of cylinder. Given head serves both as a reading and writing device. Basic "commands" are put into machine and answers are obtained from it on electric typewriters or paper tape. A total of ten typewriters can be attached to the unit at various remote locations.

Conversion from decimal to binary and binary to decimal is accomplished automatically at approximately same as maximum rate of electric typewriters, reading and writing speed of ten characters per second. Computer is installed in three cabinets.

ALWAC ELECTRONIC digital computer is constructed in Tinkertoy fashion for easy maintenance. At Logistics Research factory, girl is shown wiring up the logic chassis. Technician at right tests for wiring errors with an oscilloscope.

inert atmosphere with a "seed" crystal continually being rotated and "pulled" from the molten purified semiconductor material. Electrical characteristics of crystal must be changed during growing so that single crystal will have portions with dissimilar current-carrying characteristics. New silicon transistors are already in small but growing volume production.

Automatic Hardness Tester

QUALITY CONTROL testing of metals, both ferrous and nonferrous in hard or soft condition, can be accomplished automatically with the Rockwell hardness tester. Developed by Wilson Mechanical Institute Div., American Chain & Cable Co., the new tester operates on identical principle of hand-operated unit, but is capable of performing between 1000 to 1200 tests per hour (manual average 200 to 400).

Pieces being tested are power fed into the tester and automatically placed in position beneath a diamond penetrator. Testing loads which force the diamond into material to determine its hardness are applied and removed, resulting hardnes indicated on a dial. Minute photoelectric transistors pick up this hardness indication, transferring the reading to impulses which actuate relays. This in turn classifies material being tested according to correct hardness. The work may then be distributed for further processing or use, or returned for salvage or reprocessing.

Rockwell unit has a control which regulates up and down travel of the elevating screw so that it is not necessary to have pieces all the same thickness for automatic testing. Another control device limits dwell at end of elevating screw. Classifying is done by means of photoelectric units mounted on the bezel rings of the dial gage.

Buys Computer Facilities

MANUFACTURER of electronic tubes and components, Haydu Bros., was recently acquisitioned by Burroughs Corp. The company will continue its operation under **George K. Haydu,** formerly president, who has been named general manager.

The plant will provide specialized manufacturing facilities needed for the production of new type vacuum tubes and other electronic components.

FOR MAXIMUUM concentration of records, Diebold Inc. has developed a "super elevator file" which features ready accessibility to as many as 300,000 records. Touch of a pushbutton brings desired tray into working position. This motorized unit has an electrical control which automatically brings each group of trays to the operator by the shortest route. No record is more than 3 seconds away from operator's fingertips. Records are within easy reach for almost effortless reference or posting when clerk is seated or standing. File utilizes a wide range of record sizes and weights, handles tab cards and all popular size card records. No transcription of present records to special cards is required.

Telemetering System

RECENTLY INTRODUCED by Foxboro Co., impulse-duration telemetering system transmits and receives long distance measurements of process flow, pressure, liquid level, temperature and other variables.

Designed for reliable measurement transmission in applications such as reservoir level, natural gas line flow and pressure as well as intraplant control systems, the Teletax Telemeter can handle distances up to 150 miles by wire and may be operated over radio link or microwave channels.

Because system operates as a function of pulse duration, signal level can vary widely without affecting operation or accuracy. At 12-second intervals telemeter transmitter sends a pulse to receiver proportional in duration to the variable being measured. Receiver automatically compares duration of this pulse to that of the previous one and actuates a reversible motor which positions a recorder pen or indicator pointer to reflect any measurement change.

New Director

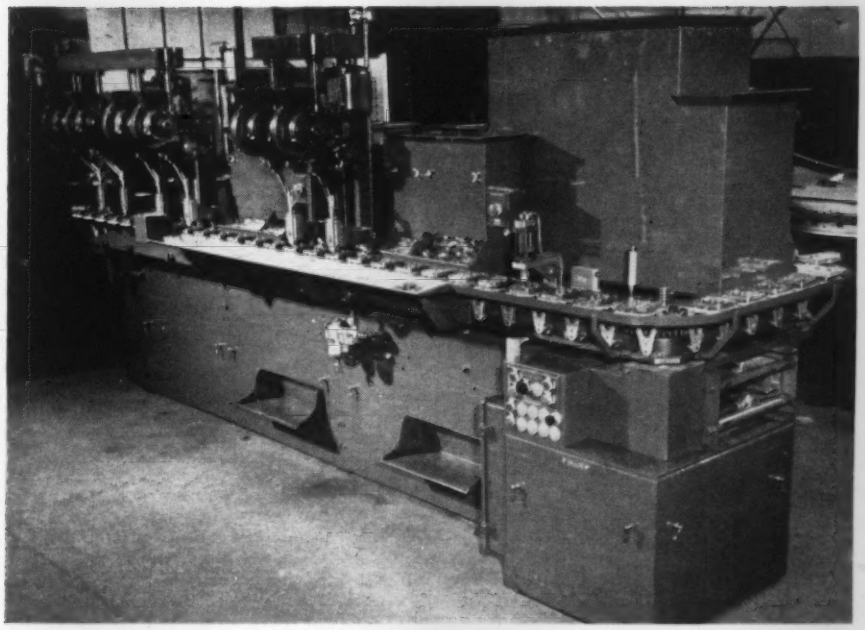
APPOINTMENT of **Virgil C. Rice** as director of manufacturing for Norge Div., Borg-Warner Corp. was announced recently. Rice will be in charge of all manufacturing, engineering and research. The new director's appointment brings him back to Norge after an 11-year absence. He comes to the company from Ronson Art Metal Works where he was vice president in charge of manufacturing.

Building for the Future

ONE MILLION DOLLAR research center which will develop new control devices for industry was recently opened by Robertshaw-Fulton Controls Co.

Dedicating the new center, **John A. Robertshaw,** president, stated, "Progress in home-living, industry, transportation and in better weapons to protect our country is largely dependent upon development of modern control devices."

New research installation forms



The Ferguson Roller Gear Drive Eliminates Another Bottle-Neck –

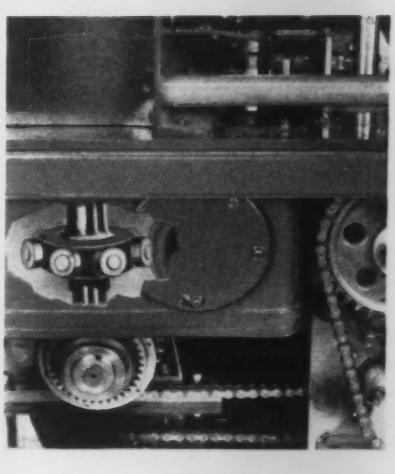
REPLACES GENEVA DRIVE IN MULTIPLE STATION TRANSFER MACHINE!

There is no place for the geneva drive in AUTOMATION . . . at least not in the straight line machines (illustration) of the nation's largest manufacturer of automotive electrical components. Geneva drives can't keep pace with modern production methods . . . in fact, **they actually create a bottleneck in the assembly line!**

New machines, incorporating the FERGUSON ROLLER GEAR DRIVE as the indexing mechanism, proved beyond all doubt that the high speed precision indexing attained with the FERGUSON DRIVE improved product quality, reduced costs materially and **increased production substantially** . . . comparisons were so amazing that the firm is now replacing geneva drives with FERGUSON ROLLER GEAR DRIVES in many of their existing straight line machines.

The FERGUSON ROLLER GEAR DRIVE, representing the ultimate in the development of cam indexing, offers tremendous advantages over geneva drives and other antiquated indexing devices — including higher speeds, greater precision, lower maintenance costs and inherent design versatility. The FERGUSON DRIVE can be installed on any machine using dial feeds, roll feeds, conveyors, carrier chains and other types of feeding mechanisms.

Don't let the rate of indexing be a bottleneck in **your** assembly line . . . not when the solution is as simple as the installation of a FERGUSON ROLLER GEAR DRIVE! Send for the complete facts today . . . ask for Catalog No. 105, which makes Drive selection as simple as choosing a speed reducer . . . no obligation, of course.



Ferguson Roller Gear Drives are available either as components or as completely housed units, in standard, semi-standard and custom-designed models. They may be designed into new machinery or added to existing machinery . . . Complete engineering service at your disposal.

Manufacturers of the Ferguson Trans-O-Mator, Ferguson Roller Gear Drives, Dial Feed Index Tables, Roll Feeds for Presses, Special Cams, Special Purpose Machinery.

FERGUSON MACHINE & TOOL CO., Inc.

ROLLER GEAR DIVISION, DEPT. B-11 **P. O. BOX 191, ST. LOUIS 21, MO.**

a major link in the company's current national expansion program which includes a $2 million plant for Bridgeport Thermostat Div. which manufactures bellows and controls utilizing bellows; a military research laboratory at Anaheim, Calif.; and new plants in Toronto, Ont. and Long Beach, Calif.

Electroplating Automatically

AUTOMATIC side arm type machine for electroplating or allied processing finishes is now being produced by Frederic B. Stevens Inc.

Christened "Stevadoer", new unit meets requirements for low head room, high lift and provides delayed set down methods, projected safety requirements, and automatic load and unload. Racks can also be conveyed to load station of plants' rack-type processing equipment—be loaded, processed, unloaded, and transferred to next manufacturing stage automatically. In addition, materials handling costs may be reduced due to machine design which allows use of standard shop conveyors in connection with either single or double row type machines.

Truck Weighing

ELECTRONIC highway scale which weighs and records both single and dual axle truck weights while vehicles are in motion, has been developed by Cox and Stevens Aircraft Corp., an affiliate of Revere Corp. of America.

Unit has been under test by the Bureau of Public Roads near Washington, D. C. for two years. First installations, now being made in Oregon, and Iowa are expected to be completed this fall.

The highway part of the device consists of a narrow level platform in the traffic lane, just wide enough to catch each wheel of the axle. This platform (3 by 10 ft) is supported by electronic weighing cells capable of accurately and instantly transmitting weight to a remotely located indicator where weight is recorded automatically. At normal highway speeds an axle will be on this platform for only 1/30 of a second.

The electronic highway scale has many applications. For research purposes, it will record axle weights, truck speeds, and axle spacings on a given roadway. This information previously was available only by count and sampling techniques, which are both laborious and expensive. Such complete data is expected to be very useful in planning and maintaining highway durability.

Used in conjunction with an overload detector, the scale will allow legally loaded trucks to bypass official state weighing stations. Now, all trucks must stop for the weighing procedure which results in costly delays even for nonoffenders.

By materially reducing the number of truck weighings at a given control station, state enforcement departments may achieve substantial financial savings in weighing crews and on stationary scale installations.

Combined Services Offered

CONCLUSION of negotiations between Dix Engineering and the Kirkhof Mfg. Corp. resulted in naming Dix as sales engineering representatives for Kirkhof in the Detroit area. Engineering services of Dix, which include design and building of special fixtures and necessary operational equipment for welding, will be augmented by Kirkhof resistance welding transformers, special resistance welding machines and automation units.

Voice "Stand-In"

AUTOMATIC STAND-IN for the human voice, developed by Salesmaster Corp., is a 10 minute capacity magnetic tape player. Unit measures 5½ by 6½ by 12-inches. Monotony is eliminated as several messages can be transcribed on the greater capacity tape. Machine regulator turns player on and off for varying periods, advances tape to next message.

Uses for new unit include: drive-in theaters to announce when next show commences, in banks to remind people of Xmas Club savings plans, in terminals to call buses, at the top of escalators in stores to call attention to merchandise displayed there, and as an automatic voice to prevent panic when fires break out.

An airline is planning to use "Salesmaster" as a standby clerk at a one-man station. While the attendant is on field meeting a plane, the stand-in will announce, "This is your agent, John Jones. I'm on the field but will be back in a few minutes. Call me if you need me."

PROBLEM OF HUMAN error in manufacturing complex electronic units has been minimized with the application of color photography known as Ecktacolor. It involves using color transparencies as a visual aid in the assembly of delicate electronic components. Ecktacolor differs from other processes in that a color negative, from which any number of transparencies can be made, is used. Considerable expense is eliminated and the risk of inferior quality that would be experienced in making enlargements from positive transparencies.

Previously, prototype models of each assembly were built and retained, serving as visual aids for wiring subsequent units. This method alone tied up costly units which could have been consigned for shipment.

Assemblers, working from blueprints and schematic diagrams, often had to refer to prototypes which necessitated their moving back and forth between work benches and the models on display. As developed by Bell Aircraft Corp., photo process has resolved this problem as each operator can have a print.

Executive Appointed

PROVIDING for anticipated future growth, **Mr. Paul Koch** has been appointed assistant general manager of Ruge-deForest Inc. Koch was formerly a consultant to the

organization. His experience includes 10 years with Bendix Aviation Corp. and 11 years with Manning, Maxwell and Moore Inc. where he organized and managed the electronics division.

Principal products of Ruge-de Forest are load and pressure sensitive devices and instrumentation based on bonded resistance wire strain gage.

Power Show Reacts to New Era

ADVANCES in automation, ranging from automatic regulation of a single mechanical operation to control of an entire power generating station, will be demonstrated at the 21st National Exposition of Power and Mechanical Engineering to be held Dec. 2 to 7 in Philadelphia.

One company in the automatic controls field will make a first-time showing of an all electronic load and frequency control system for power generating systems. This system employs continuous pulse-rate telemetering to insure sensitivity and accurate readings, and may be installed with any form of transmission, such as wire, controlled carrier, or microwave. Choice of control method is also possible, including frequency, schedule, tie-line bias, manual control, and override. Control devices are applicable to a single plant or a system incorporating several plants and network distribution.

Exhibitor of reactor equipment, the American Machine & Foundry Co. is actively engaged in unitizing reactor components under a standardization program set up early in the present year. Some of the units are already in the prototype stage. Research reactor control systems presently being developed will include shim and regulating rod drive mechanisms and associated mechanical gear, rod guides, lattice assemblies, bridge mountings for control equipment, a variety of irradiation devices, and handling tools.

Television exhibitors will show new cameras for industrial application which will permit events to be observed in power and processing plants, that were once beyond

NEW ferguson ***Intermittor***

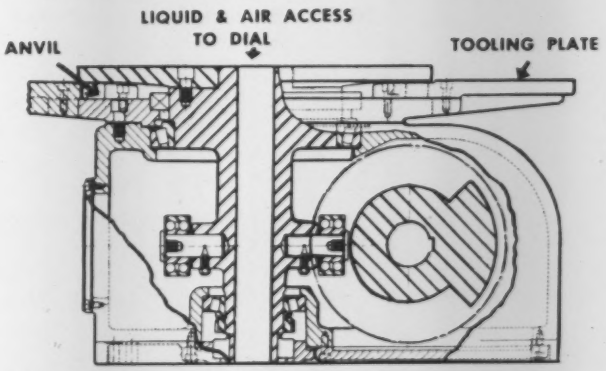
INDEXING TABLES

with the
FERGUSON ROLLER GEAR DRIVE

HIGH-SPEED PRECISION:
up to 500 indexes per minute

LOW MAINTENANCE:
20,000 hours operation with absolutely no maintenance

4 to 24 STOPS:
standard models



THE FERGUSON INTERMITTOR

Note channel for air or liquid through the dial and roller gear to the tooling stations.

Cut production costs with the new FERGUSON Intermittor, the standard index table that features *high speeds* with *smoothness* of operation; extreme *precision* with no shock-causing auxiliary locking or locating mechanisms; up to 20,000 hours operation with *no maintenance* and complete drive renewal merely by replacing inexpensive ball bearings.

Smooth starts and stops with precision locking are inherent in the Intermittor. There is no need for costly, jarring, wearing auxiliary devices, even at highest speeds.

The Intermittor gives you complete choice of profitable work time with a minimum of "wasted" rest during the cycle because movement time may vary from 25% to 100% of the total cycle time. You get more pieces per hour . . . at less cost per piece.

Standard FERGUSON Intermittors are available with the number of stops varying from 4 to 24. Custom designs are possible with any number of stops and with any proportion of work time to rest time. They offer the ideal solution to the difficult indexing problems that may arise in your conversion to automation.

WRITE FOR INFORMATION—NO OBLIGATION

Our new catalog, giving complete information and data about drive selection, is yours upon request. It makes selection as simple as choosing a speed reducer...write for your copy today, no obligation.

Manufacturers of the Ferguson Trans-o-Mator, Ferguson Roller Gear Drives, Dial Feed Index Tables, Roll Feeds for Presses, Special Cams, Special Purpose Machinery.

ferguson

FERGUSON MACHINE & TOOL CO., INC.

ROLLER GEAR DIVISION, DEPT. BI-11 P. O. BOX 191, ST. LOUIS 21, MO.

the range of human vision, particularly events occurring in remote or hazardous locations.

Another exhibit, opening wide new uses in power and industrial plants, includes noise measuring instruments, stroboscopes, voltage regulators having a high rating (6KVA), improved speed response (20 v/sec), and unusual accuracy (0.25 per cent); also speed controls for small motors, which avoid the use of electron tubes.

Division Manager Named

APPOINTMENT of **Stuart Edgerly** as manager of the newly-formed industrial sales division of Fenwal Inc., manufacturer of precision temperature controls and overheat detectors, has been announced by the company's board of directors. In his new capacity Mr. Edgerly

will co-ordinate sales of industrial temperature controls through the organization's 32 field offices. Prior to joining Fenwal, he was with Fairchild Camera and Instrument Corp., serving as assistant to the vice president for sales and subsequently as sales manager for the potentiometer division.

Linear Programming Seminar

PURPOSE of a three-week seminar on linear programming, to be held Hotel Cleveland, Nov. 1 to 19, is to bridge gap between theoretical and usable aspects of this new technical field. Number of specially prepared texts will be used which are based on result-getting applications developed in field work. Seminar is being sponsored by Executive Services, management consultants. Conducted by their own staff and supplemented by outside experts, training program is under the direction of **Nyles V. Reinfeld. Dr. E. Leonard Arnoff** of Operations Research Dept. of Case Institute of Technology and **Dr. T. M. Whitin** of Massachusetts Institute of Technology's School of Industrial Management will lecture in their specialized fields.

Streak Camera

WITH ADDITION of control facilities, Beckman & Whitley Streak Camera becomes a complete system for synchronized recording of position vs. time data. In use, the instrument makes a plot on 4 x 10 inch film where the vertical axis represents space and the horizontal axis represents time.

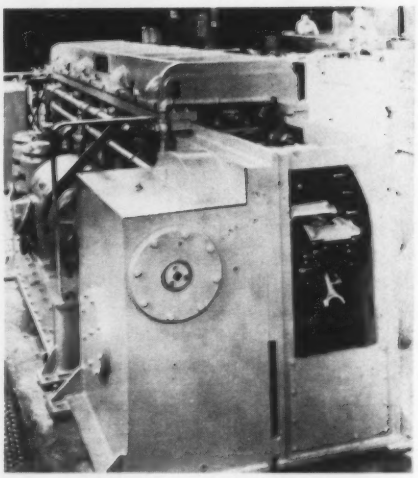
Transient events such as explosive, flash-tube, shock-wave and spark-discharge phenomena are suitable subjects providing they can be controlled with respect to time co-ordination. Self-luminous events, as well as schlieren and interferometric effects can be recorded.

An external objective lens images the event on the camera slit. An internal lens forms an inverted, approximately 1-to-1 image of the slit on the face of a polished steel rotatable mirror. When the mirror is being driven at its maximum speed of 50,000 rpm, the image is swept across the film at a writing rate of 5.46 mm. per microsecond, and a film-length writing time of 44 microseconds.

Because of high speed mirror rotation, camera housing is operated under vacuum. Vacuum pumps as well as electric driving facilities for the high-speed mirror are all housed in camera unit. Included in the control console are facilities for remote operation and monitoring of events under study.

New V.P.

FORMERLY with the Philadelphia Gear Works, **Jules F. Fritts** has joined the Mercer-Robinson Co. of New York as executive vice president. Manufacturing divisions of Mercer-Robinson produce materials handling and processing equipment.



REALIZING that some form of automation was the answer to increase broaching parts production, the Lapointe Machine Tool Co. designed, developed and is now manufacturing a horizontal type continuous broaching machine. A production rate of 900 parts per hour can be obtained in broaching the sides, face and half-round of an automotive connecting rod while the machine is operating at minimum speed. When broaching at top speed, production rate can be doubled. The part is the customary steel forging, amount of stock removed is approximately ⅛-in. per surface. Built with a 120-inch stroke, the machine is powered by a 30 hp motor. The unit is designed with a series of individual self-operating, self-locking and self-clamping fixtures arranged so that the operator merely has to insert the parts into work "nests". Machine will stop automatically if something should occur that interferes with its normal operation.

MEETINGS AND EVENTS

Nov. 4-5—

Society of Automotive Engineers. National Fuels and Lubricants meeting to be held Mayo Hotel, Tulsa, Oklahoma. Additional information may be obtained from society headquarters, 29 W. 39th St., New York 17.

Nov. 8-11—

Wire Association Meeting. Annual fall meeting to be held Hotel Statler, Detroit. Additional information may be obtained from Richard E. Brown, executive secretary, 453 Main St., Stamford, Conn.

Nov. 8-12—

National Electrical Manufacturers Association. Annual meeting to be held Chalfonte-Haddon Hall, Atlantic City. Additional information may be obtained from W. J. Donald, managing director, 155 E. 44th St., New York 17.

Nov. 11-12—

AMA Office Management Seminar. First of three meetings to be held AMA headquarters on initiating and developing an office work-simplification program. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

Nov. 28-Dec. 3—

American Society of Mechanical Engineers. Annual meeting to be held Hotel Statler, New York. Additional information may be obtained from C. E. Davies, secretary, 29 W. 39th St., New York 17.

Nov. 29-Dec. 1—

AMA Office Management Seminar. First of two meetings on developing and administering a clerical work-standards program. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

Dec. 2-7—

ASME National Exposition of Power and Mechanical Engineering. Twenty-first exposition to be held Commercial Museum, Philadelphia. Additional information may be obtained from E. K. Stevens, exposition manager, 480 Lexington Ave., New York 17.

Dec. 5-9—

Scientific Apparatus Makers Association. Annual fall meeting to be held Pinehurst Hotel, Pinehurst, N. C. Additional information may be obtained from Kenneth Anderson, executive vice president, 20 N. Wacker Dr., Chicago 6.

Dec. 8-10—

Eastern Joint Computer Conference and Exhibition. Fourth annual conference and exhibition to be held Bellevue-Stratford Hotel, Philadelphia. Additional information may be obtained by writing Eastern Joint Computer Conference, P. O. Box 7825, Philadelphia 1.

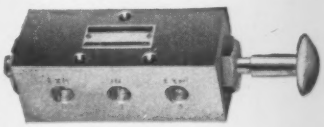
Dec. 9-10—

AMA Office Management Seminar. Second of three meetings to be held AMA headquarters on initiating and developing an office-work simplification program. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

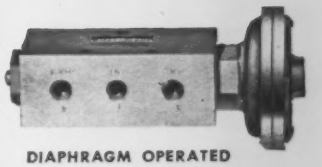
NEW, INEXPENSIVE, HIGHLY EFFICIENT

"O" TYPE" Quick-As-Wink® VALVES

NOW AVAILABLE

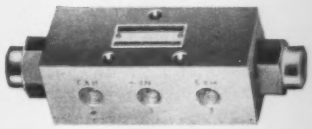


BUTTON OPERATED
(Push-Pull or Push Spring Return)

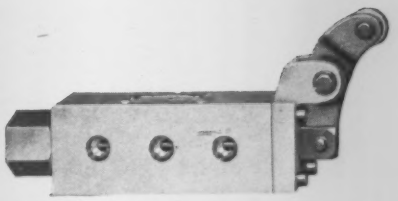


DIAPHRAGM OPERATED

FOR A WIDE

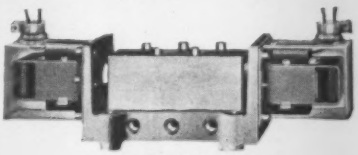


PILOT CYLINDER OPERATED
(Single or Double Pilot)

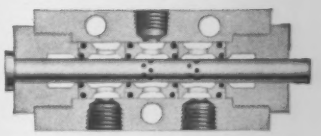


CAM OPERATED

VARIETY OF SERVICES



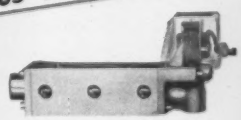
SOLENOID OPERATED
(Single or Double Solenoid)



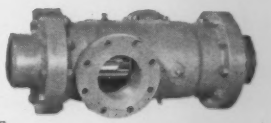
CUT-AWAY VIEW OF INTERIOR
U. S. Pat. No. 2,645,450

● These newly developed valves combine greatly simplified construction, positive positioning of all parts and quick, easy repacking in the field. There is no direct impingement of flow across the packings, greatly prolonging their life. All metal parts are aluminum except the hollow, radially ported, stainless steel plunger. ⅛" and ¼" pipe connections. 2, 3, 4 and 5-way actions. Write for Bulletin No. 531 today! *It gives full details.*

Ask us also about . . .



SINGLE PLUNGER SOLENOID VALVES in single or double solenoid designs. Low amperage requirement eliminates intermediate relays and simplifies electrical control circuits.



WATER SYSTEM VALVES pilot cylinder operated, sizes to 8". Can be installed with automatic remote control as a plant protection measure to shut off water to certain parts of the plant in case of emergency so the entire available supply is directed where it is most needed.

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

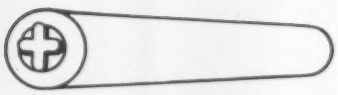
Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 2074 East Pershing St., Salem, Ohio

THIS IS AETNA-STANDARD

SEAMLESS TUBE MILLS

Aetna continues to conceive many new ideas for the production of seamless tubing. This continued progress, plus reputation and experience, helps Aetna-Standard to continue as world's leading designer and builder of Seamless Tube Mills.

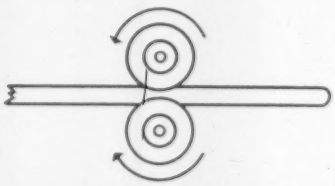


ROLLS

Aetna specializes in manufacture of small and medium-sized iron-base rolls. Aetna is pioneering in the use of Nodular Iron for rolls and castings under trade name of Magaloy.

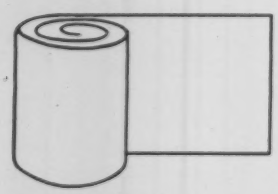
FLAT-ROLLED FINISHING EQUIPMENT

This is one of Aetna's six major product lines. Flat-rolled embraces such equipment as: Shearing and Classifying; Scrubbing and Drying; Recoiling; Slitting and Side Trimming; Roller Levellers (two-high and four-high); Reels of all kinds; and many other products.



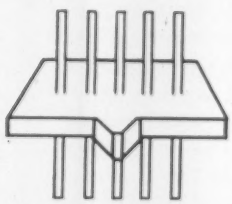
CONTINUOUS BUTT WELD PIPE MILLS

Over the years, new ideas and engineering accomplishments have strengthened Aetna's position as the only builder in America of Continuous Butt Weld Pipe Mills. In recent months, Aetna Pipe Mill equipment has been installed in America, in Canada, in Germany, in England, in Japan and in Argentina.



CONTINUOUS COATING

This year Aetna will have completed the building of 25 continuous galvanizing lines, in addition to several terne and electrolytic tinning lines. Aetna has worked closely with industry in this development and is considered the pioneer in continuous coating equipment.



COLD DRAWING

The world over, Aetna-Standard is recognized as the leading authority and builder of cold draw equipment for tubes and bars. This year marked introduction of several innovations by Aetna, such as the air gripper carriage and hook.

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England—Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.
Standard Engineering Company, Ellwood City, Pa.
Trans-World Traders, Pittsburgh, Pa.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

No Robots Here!

Owing to the magic and glamour surrounding such modern developments as electronic controls and various computer systems, there has been an abundance of rather fictional reports concerning automation. In some instances today's automatic controls have been termed "robots", silent and insidious. In others it is said that robots outnumber workers.

To term automatic controls robots is absurd. Nothing could be farther from fact, a robot being classically defined as a manufactured mechanical person without sensibility—any automatic apparatus or device that performs functions ascribed to human beings. No robots by any accepted definition are in use today and the basic electrical controls of the types used on automotive cylinder block transfer machines referred to by such writers have been in use for many years.

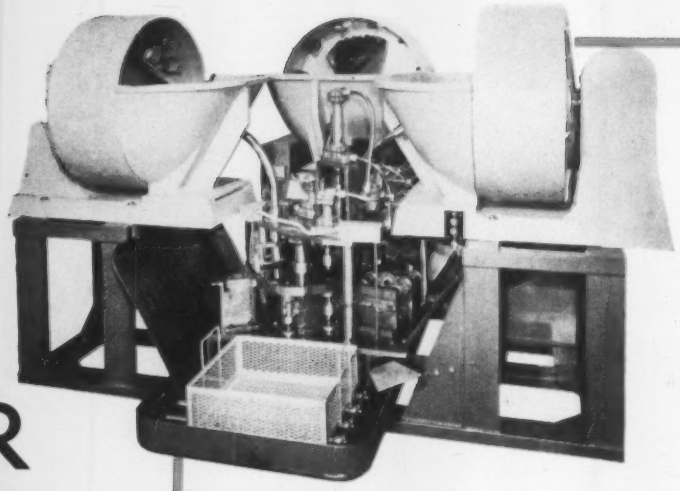
The tremendous growth of automation across all industries has naturally created considerable interest. But, to relegate such straightforward engineering developments to the limbo of witchcraft, as is the wont of popular writers, is unfair to engineers and laymen alike. It could well delay normal development of automation and its benefits severely.

By faithful adherence to fact and careful avoidance of the unwarranted tendency toward the sensational, all parties will benefit. To imply that robots are superceding men is gross misstatement of fact. The foolproof machine which "gets no headaches", the "noiseless plant devoid of moving parts", and the "substitution of automatic for human processes" are cuts from pure cloth.

Actually, the automatic telephone systems of today, the automatic machines and the automated plants require more and better trained men to achieve continuous and successful operation. Automation offers more and better goods and services, faster and at lower cost than ever before in history but behind it all lies a tremendous work force of engineers and technicians who make it possible. No robots here!

EDITOR

AUTOMATION



DESIGN FOR MANUFACTURE

A "MUST" FOR AUTOMATION

Economically feasible automation in manufacture is tied up closely with design suitability. Design for mass interchangeable manufacture becomes a stepping stone but working automation may require rethinking and redesign for acceptable results.

By ROGER W. BOLZ
Editor

CASE 1

Increased output and uniform quality are achieved with automated production equipment. Ingenious machine design provides continuous precision operation under controlled conditions on jobs ordinarily delegated to conventional methods. Here, two metal shells are assembled with a rubber bushing.

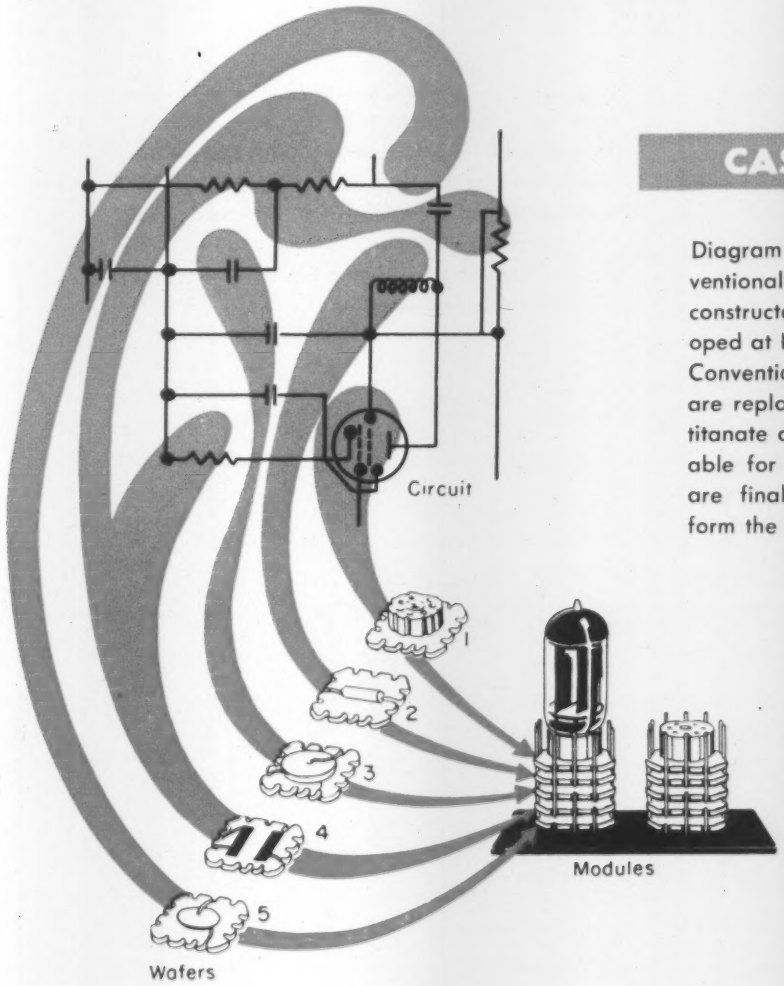
OVER THE YEARS many engineering developments have compounded to lay the groundwork for today's automation. A keen insight into the many important facets of design and production and their integration and co-ordination are desirable to create the climate conducive to economically sound automation.

Not the easiest of engineering achievements, true simplicity of design on a broad scale is a basic "must" for real progress toward automation. Design for production today offers even greater economic benefits than ever before, and especially so where automatic production is contemplated. But to plan and design most effectively it is necessary to understand the concept of automation and its underlying basic philosophy.

Mass Production—A Step

Automation should not be confused with ordinary mass-production techniques. Mass production, as developed from the original ideas of Eli Whitney, comprises the basic approach and science of manufacturing without individual fitting quantities of products from groups of components produced in mass. Mass production is made practicable by dimensional standardization of components to permit interchangeability in assembly. Manufacture may be entirely by hand methods from start to finish. Mass-production techniques, therefore, constituted a major step in creating the possibility of providing large quantities of complex products with superior quality and uniformity at lower cost in time and money.

However, despite years of development and refinement these conventional hand methods for producing discrete products in many instances no longer suffice. Economics, market demand, drudgery, speed, monotony and other factors necessitate a change. The succeeding step is automation. To the basic science of mass production, the newer modern evolution of automation is applied to pro-



CASE 2

Diagram showing the progression from a conventional amplifier circuit to its counterpart constructed according to the principles developed at NBS for modular design of electronics. Conventional resistors, capacitors, and coils are replaced by wafer-mounted tape resistors, titanate capacitors, and miniaturized coils suitable for automatic manufacture. The wafers are finally assembled skyscraper fashion to form the modular type unit.

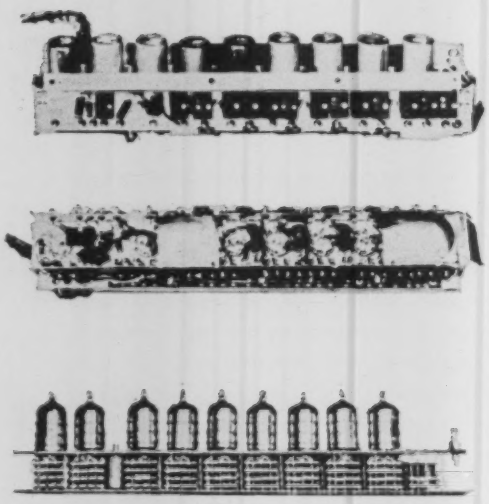
duce the result of automatic production. Here, the basic ideas of automatic operation—originally conceived by Watt for the steam governor; by Sickels, Gray and Farcot for servo steering and gun positioning; by Jacquard for the cotton loom; by Dennison for watchmaking; and others—merge to create the modern broad concept of automation as applied to manufacture as well as processing.

Perfection, to a certain degree, of mass-production technique was a natural forerunner of automation in manufacturing. Its achievements have also contributed significantly to all commercial and industrial automation, for today automation is dependent upon accurate, intricate and serviceable equipment. Automatic operation aimed toward complete plant automation requires a neat combination of equipment, machines and controls. Being —in simple terms—manufacturing, processing or performing of services as automatically as possible, automation comprises automatic machines; automatic controls; automatic methods such as handling, processing, assembling, measuring, sensing, packaging; and automatic computers and data handling systems. Thus, with the right combination of elements properly integrated and co-ordinated to suit demands, conditions and economics, amazing achievements are possible. But, the best in long-life and performance is needed in such equipment—and today this ultimate is much closer to achievement.

▶ Design for Production Needed

Real economy in mass manufacture of products has been to a large degree tied up with good design for production, but failure to insure optimum design features has seldom denied satisfactory results. Actually, it has even been possible to defy good design criteria and depend on the skill of the men along the lines to supply the necessary correction factors. Not so in automation. Mere mass production techniques must be superseded by mod-

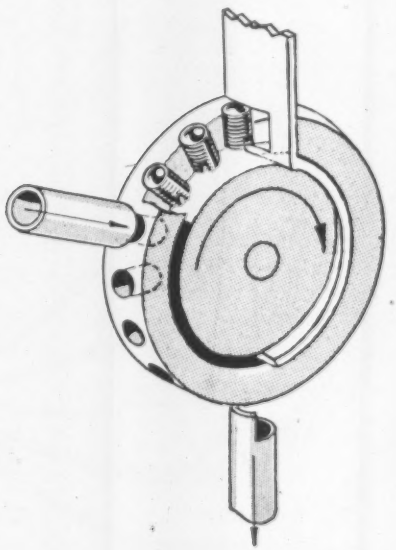
CASE 3



Intermediate frequency amplifier employed in a manufacturing cost determination conducted by Mead Carney and Co. Cost of this unit (top), constructed in large numbers by conventional manual techniques employing conventional component parts, was compared with the costs of production using both mechanized and manual methods for manufacturing the modular design. A compromise between the latter two proved most economical.

CASE 4

A great variety of piece-parts have been handled and fed automatically in production. Parts should have stability of physical outline, reasonable uniformity and preferably some definite shape characteristics to insure practical feeding and orienting. Here three methods are shown for feeding headless setscrews all with nose end leading.

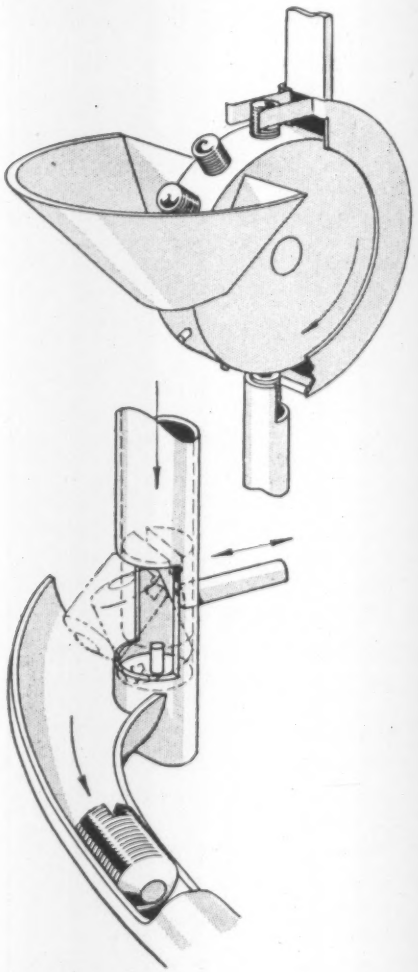


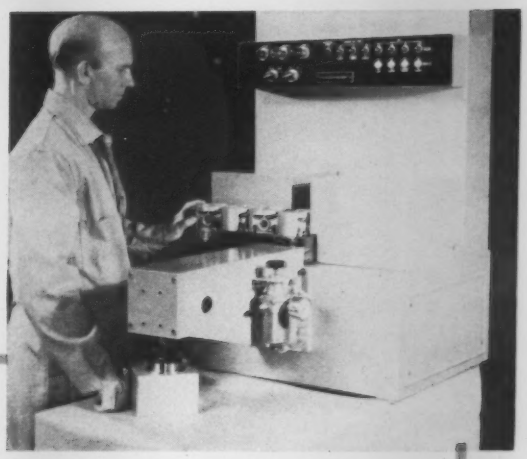
ern production design for automatic manufacture. Although in many instances production of components and assemblies has been automated without design change, in most cases significant savings await ingenious design modification.

This is especially true of automatic assembly. To attempt to assemble automatically without design modification would parallel the attempt to mass produce without regard to the technique of interchangeability. Today, with automation, simplicity is the byword. And in many cases, even arduous labor and large expenditures may not provide the desired economic result. The much publicized Project Tinkertoy bears this out. After thorough economic studies were completed it was found that semimanual methods offered the most effective result, not complete automation.

In this analysis of the project it was found that the electronic amplifier of simplified modular design reduced manufacturing cost 38.5 per cent over conventional piecemeal design. This method consists in hand assembling the simplified machine produced components. Fully mechanized production of the same modular design reduced cost 44 per cent with roughly the same output per hour. However, seven of the process steps proved to be lower in cost with the hand method and when substituted in the otherwise mechanized procedure the combination offered the lowest total cost per unit.

Significant factors in the project were that $665,000 was required to create the all automatic facility and $82,000 the semimanual. Little savings would accrue from increase in size of either facility. Limitations on the output, and hence economics, of the mechanized production installation were found to center around equipment cyclic rates, machine delay time, reject percentage, equipment costs, numbers and skills of operators, and equipment maintenance. This example merely indicates that automation is not a panacea. As always, a neat overall compromise provides the best end result.





CASE 5

In-process gaging device designed by Sheffield that checks seven piston dimensions automatically—diameters of top land, top groove, second groove, oil groove, and widths of top, second and oil grooves. Pistons are progressively moved into two gaging stations by air-operated push bar. At first station widths of ring grooves are gaged with "go" and "not go" rolls. If grooves are out of tolerance, a memory circuit rejects the piston at the next station. Second station gages ring groove and diameters. Pistons out of tolerance drop through a trap door while acceptable units leave via a rear chute.

▶ Quality and Design Factors

Another area that assumes key importance in automation is statistical quality control. Although desirable in ordinary mass production, it is neither always used or a "must". Common methods of gaging after manufacture without machine control are still commonplace and, by and large, still suitable to a degree. To permit economic automatic assembly or automatic production of just piece-parts, in-process continuous gaging to eliminate scrap and off-size pieces is desirable and often a necessity. Though not commonly recognized, feeding, chuting, orienting and assembling operations in automation fail most often because of non-uniformity of parts.

Through automatic size and uniformity control of parts being produced, production of bad pieces is eliminated. Although of little economic importance in production for hand assembly (where scrap can be detected by the assembler), in-process gaging before continuous production assembly operations is a vital factor. Extremely small irregularities can jam intricate devices easily, and hence, crude operations are often impractical to automate.

Here, again, design for economical automatic production assumes critical importance. Individual piece-parts can be designed for maximum facility in the production process; in the gaging procedures necessary; in the handling, chuting, orienting and feeding steps required; and in the actual assembly arrangement. These overriding considerations in basic design detail which must be brought into play can also, and often do, contribute direct additional benefits. Typical cases on record show that the constant drive toward suitability for automation procedures and for simplicity result in much superior end products from standpoints of performance, uniformity, stability, service life, and maintenance. The overall economic results not often recognized constitute an advance worthy of note in any management planning.

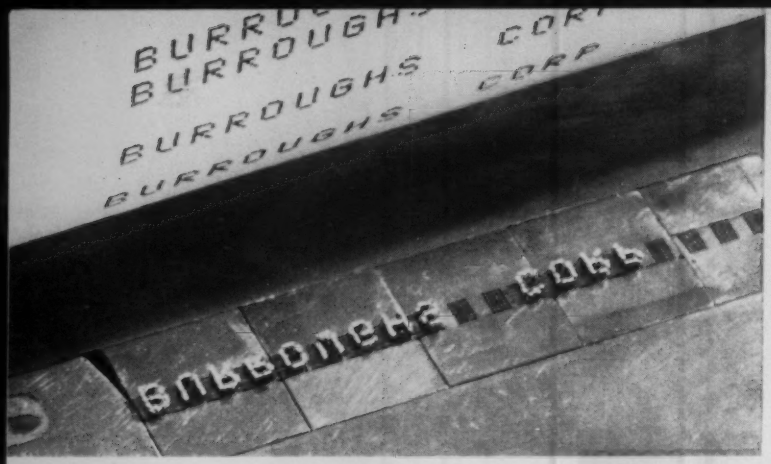


Fig. 1—In the print head section, extension of the printing wires from their supporting matrices has been exaggerated, and the wire ends colored in order to illustrate the formation of characters. In actual operation, the wires move approximately 0.020 in. To print, a one-time carbon ribbon and the paper are run between the matrix surface and a flat steel platen (not shown). Impact of the wires in the carbon transfers a pattern of carbon "dots" to the paper, forming the printed characters. Paper movement runs parallel to the matrix surface, stops 15 milliseconds to print a line, then advances to the position required to print the next. Characters in each line are printed simultaneously

HIGH-SPEED PRINTING

KEEPS PACE WITH ELECTRONIC DATA HANDLING

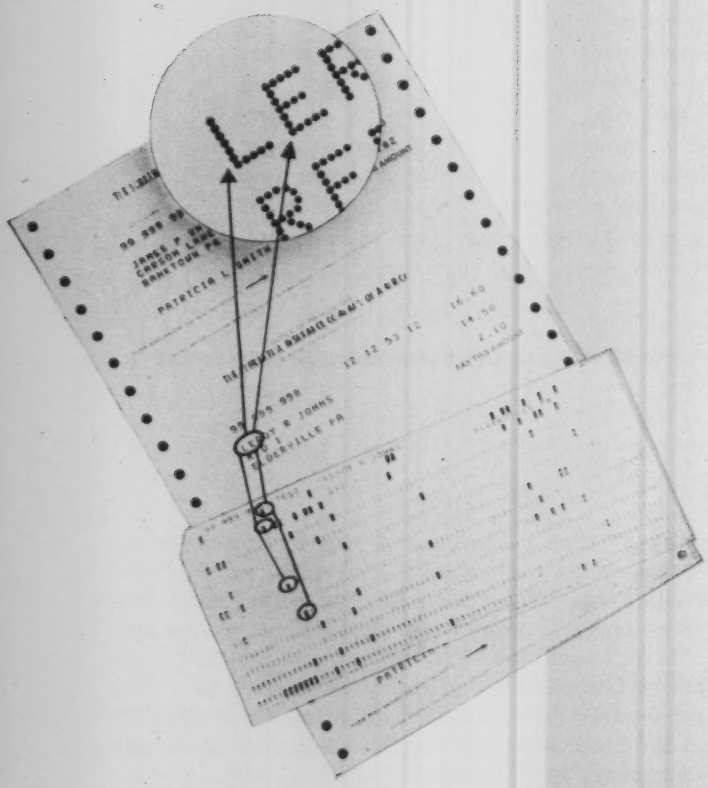


Fig. 2—Letters, numbers and special characters are printed in form of "dot" patterns as shown in the circled enlargement. The dots of each letter or character are printed by means of tiny wires (0.010 in. diameter in a matrix 5 wires wide by 7 high. Information to be printed is fed into the machine in the form of standard tabulating cards similar to the card shown at the bottom of the illustration. As the cards pass through the two card-feeds at the rate of 54,000 lines an hour, electronic decoders interpret the punched holes and cause the printing mechanism to select and actuate the proper wires in each matrix to print the desired characters

INPUT AND OUTPUT devices for computing machines have been the subject of much development effort because their speeds are not compatible with the electronic calculating elements. While "memories" have eased the problem by providing storage space for data, great differences in time requirements for different computer functions have hampered the application of electronic data handling to clerical work.

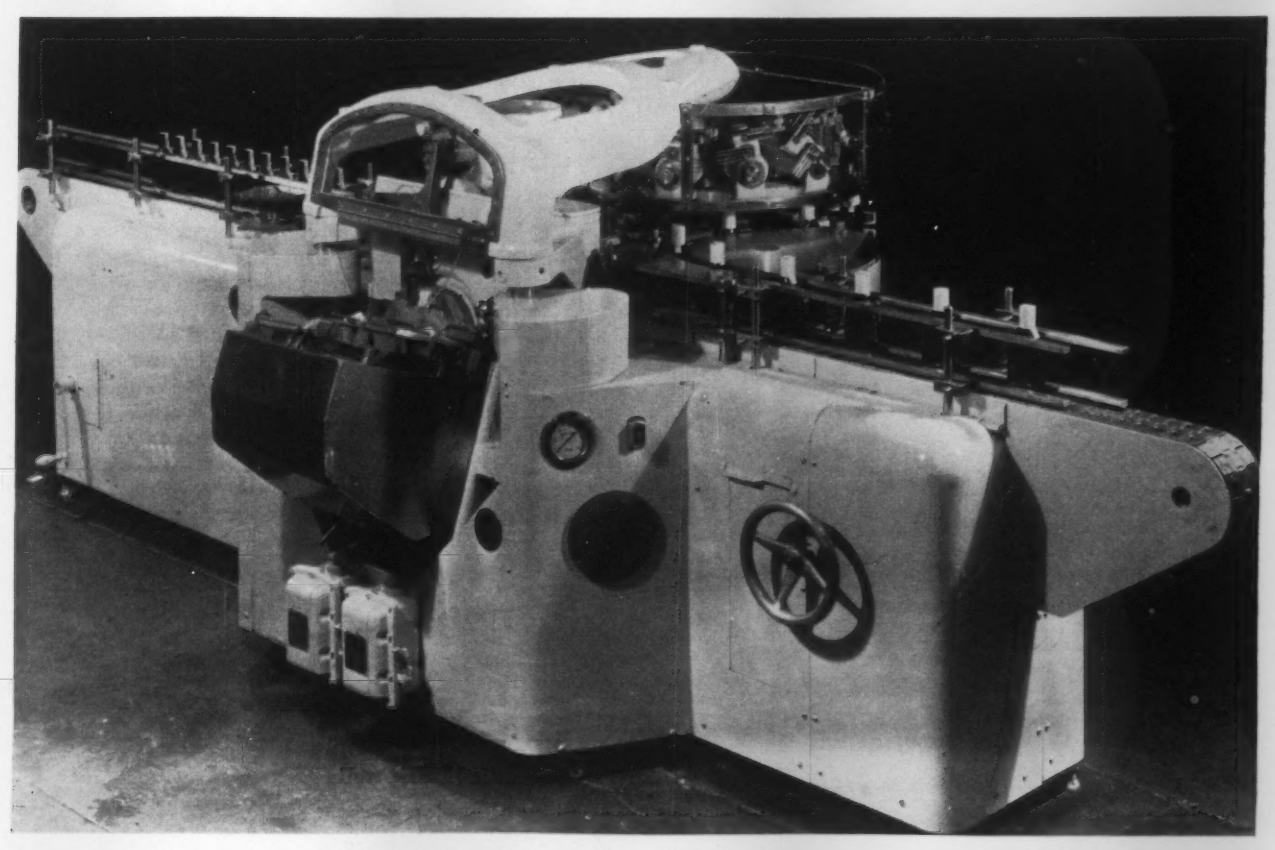
A development by Burroughs Corp. has increased output printing speed sufficiently to broaden the range of practical applications for electronic office equipment. Operating at a speed of over 43,000 characters a minute, the equipment can simultaneously print and punch in a single operation.

Alphabetic, numeric, and special characters are formed by wires in a mosaic, *Fig.* 1, each wire individually activated and positively driven in both printing and restoring directions. An electronic decoder reads the punched holes and selects the proper wires to form the desired character, *Fig.* 2.

Synchronized with the printer unit, the punching mechanism can punch any selected data from input cards, accumulators, or digit emitters directly into the same tabulating card document that has just been printed.

Principal applications are expected in public utility companies, publishing and mail order concerns, and insurance companies where there is a large volume of accounting records, promotional and mailing pieces. In preparing utility bills, for instance, customer cards would be placed in one feed hopper of the card reading unit, billing information in the other. With one pass of the two sets of unmerged cards, the machine would produce a postcard with name and address printed on one side, and meter reading, rates, dates and charges on the reverse side.

In the same operation, the stub would be punched with the account number and amount for crediting when payments are received; a separate punched card would be created for use of the meter reader on his next round; totals for proof and analysis would be provided and a register furnished containing all billing information.



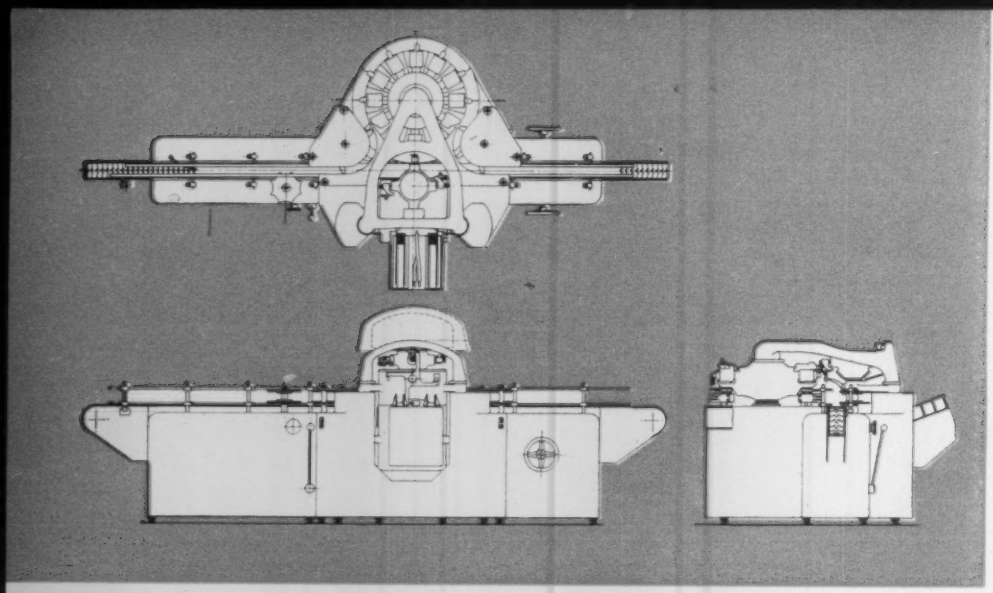
1 General view of neck band sealing machine; bottles come in from strip stamp machine at left, travel around rotary table in rear where cellulose seal is applied, and move out to next operation at right.

AUTOMATION TODAY

APPLYING BOTTLE SEALS

ONE OPERATION often required in the line sequence of bottling liquor, wine, chemicals, pharmaceuticals, and certain liquid foods is the placing of a cellulose band seal around the neck of the bottle and its closure. To maintain line speeds of up to 165 bottles per minute, the Gisholt Machine Co. has developed an automatic machine that takes each folded cut length of the tubing from a stack, opens it into cylindrical form as it is passed through a series of transfer finger mechanisms, and deposits it over the bottle.

Bottles are received from the previous operation on a flat top chain conveyor, which is an integral part of this machine, and are transferred to a 12-station rotary index table. As the bottles move around this table, each one of the set of 12 final



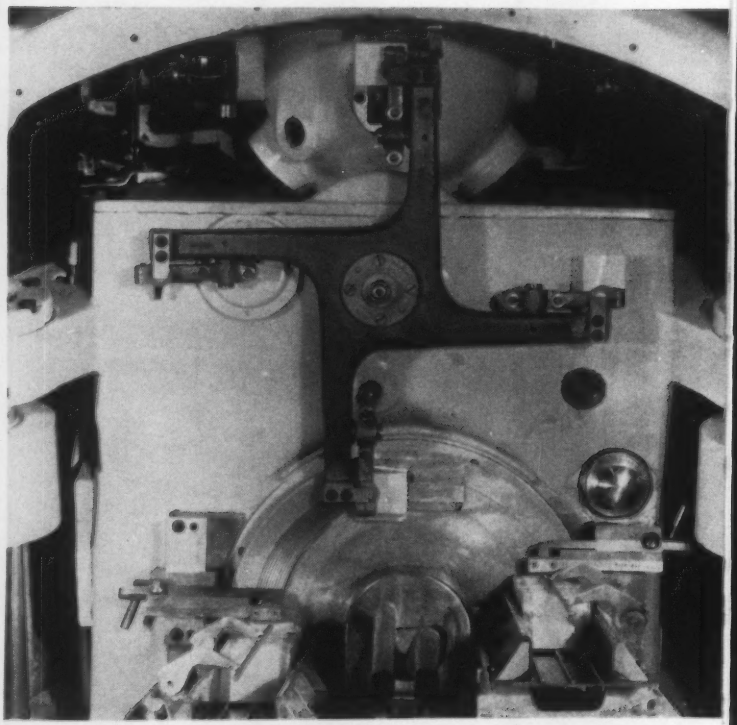
2 Elevation and plan drawings show loading magazines; four-arm transfer mechanism; four-station, two-finger head turret; and 12-station, eight-finger head turret. In setup for different height bottles these seal handling mechanisms are raised or lowered with respect to the conveyor and rotary table. Bottle guides and clamps are adjustable to various sizes.

APPLYING BOTTLE SEALS

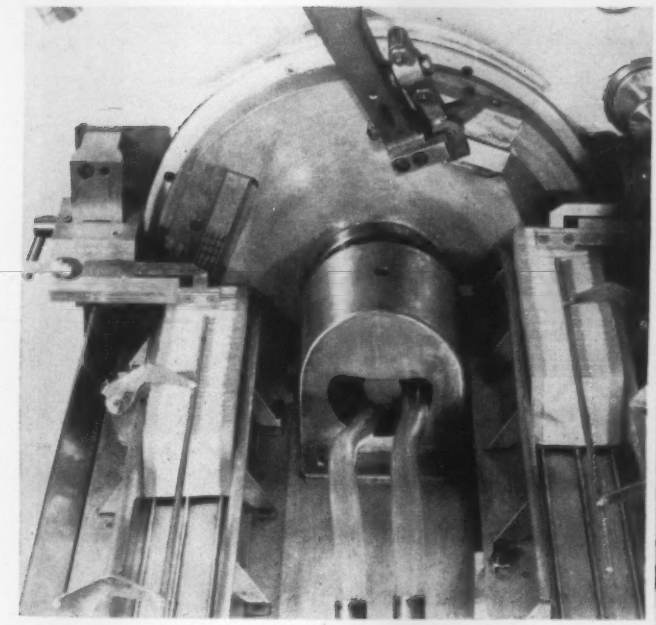
finger heads completes its cycle in turn by positioning the neck band before the bottle moves back onto the conveyor to be carried on to the next operation.

Certain features of this packaging machine, engineered by a machine tool builder, are of particular noteworthy interest. Rather than have each bottle shuttle in and out of a fixed loading station with the resulting difficulties of high-speed intermittent motion; the actual assembly is performed in a work station that moves with the bottle in a smooth running continuous action. The transfer heads and feeding devices incorporate antifriction bearings in totally enclosed oil filled gear boxes to require a minimum of maintenance. Safety clutches and plastic guards decrease the possibility of operating accidents.

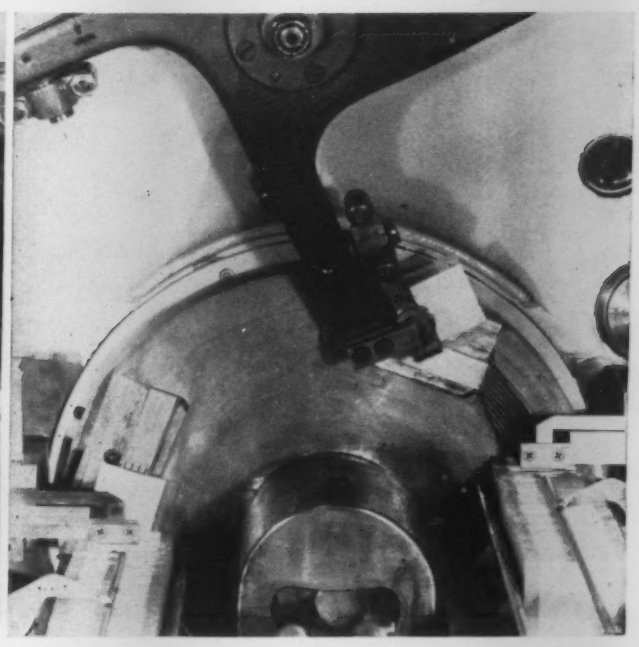
These considerations and the mechanics of action are illustrated in the accompanying pictures of the automatic machine sequence.



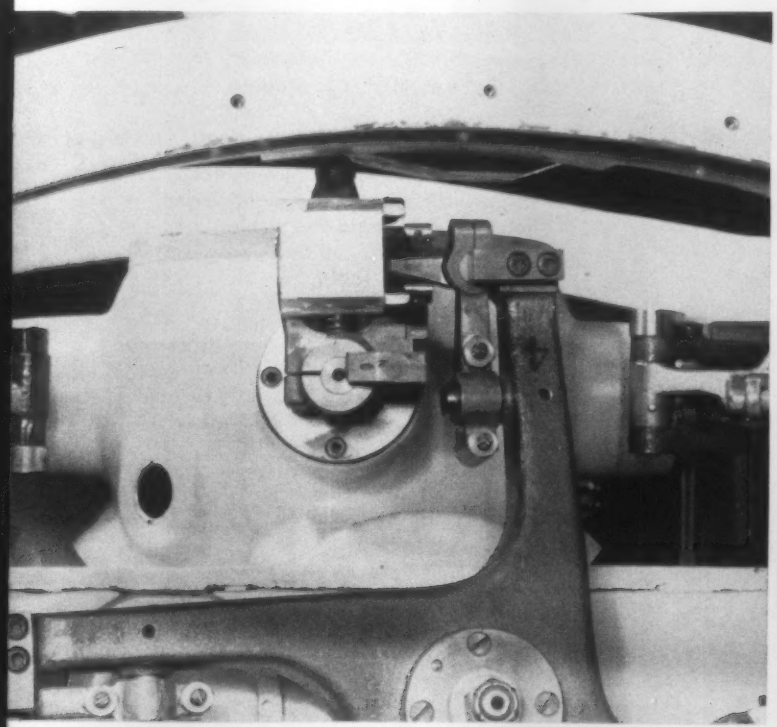
5 Transfer arms deliver seals at the level of the two-finger head turret assembly which is a four-station turret rotating on a vertical axis.



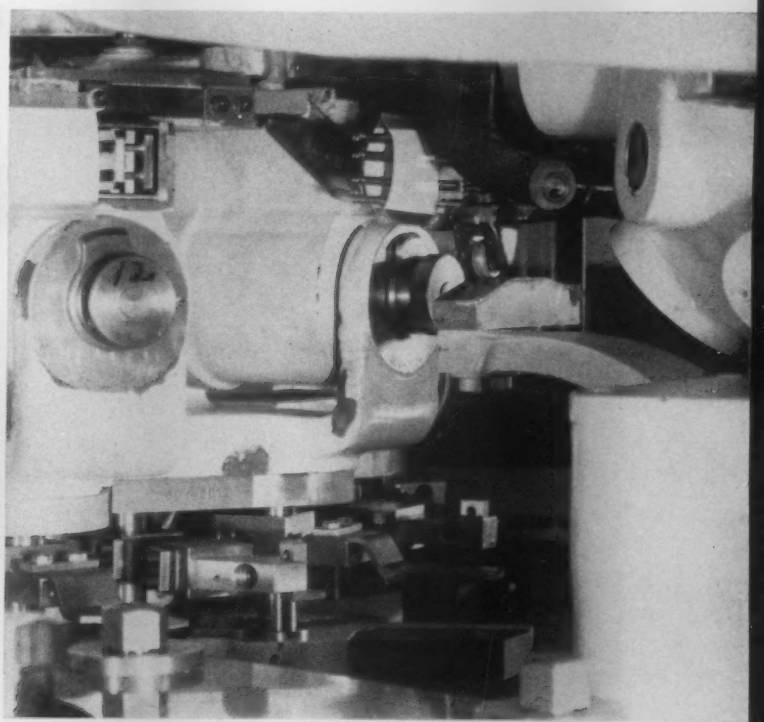
3 Operator loads cut seals into two self-aligning and self-feeding magazines at front of machine. Oscillating disk uses vacuum to pull individual seals alternately from each line and position them for the pick off finger.



4 Single finger and clamp on end of rotating four-armed transfer mechanism enters seal and takes it from oscillating disk. If no bottles are in machine, finger does not take seal.

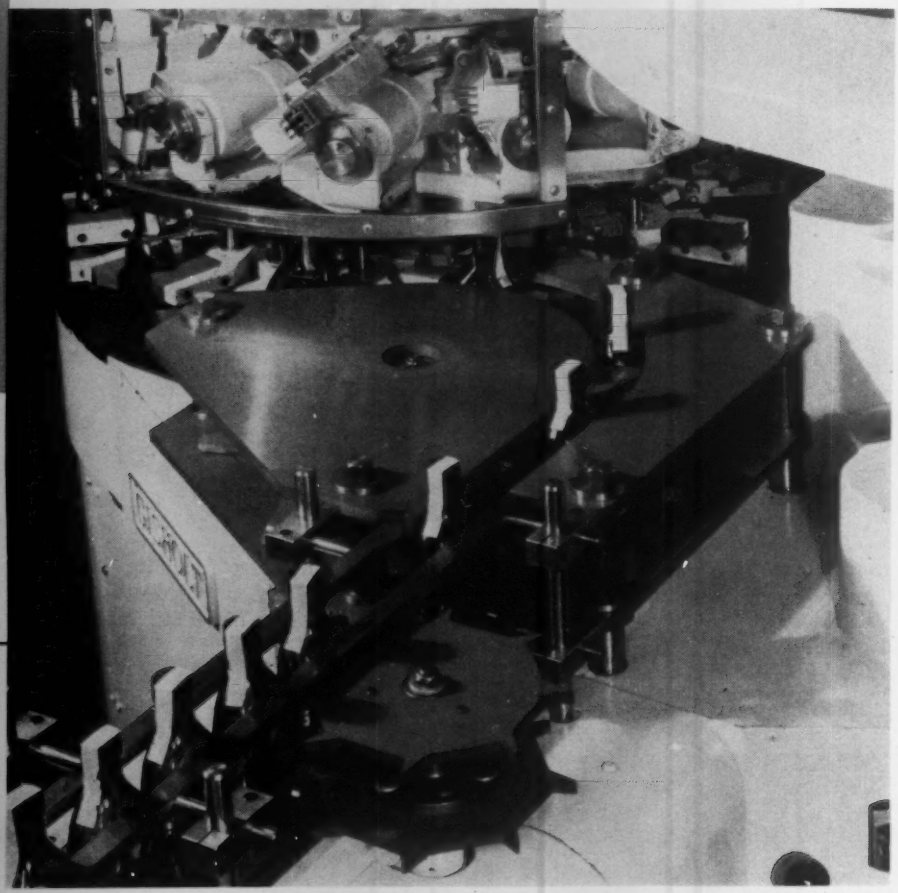


6 Cam bar on upper frame causes fingers in two-finger head to close for entry into seal at same time as cam bar on front of two-finger head releases clamp on transfer arm. View shows seal removed from transfer arm finger and positioned on two-finger head.



7 Two-finger turret (Upper left) has rotated 180 degrees, and two-finger head has turned 180 degrees on its own axis to be in position for eight-finger head to enter seal. At this position, cam actuates lower one of the two fingers to release seal so that the collapsed eight-finger assembly may take it.

APPLYING BOTTLE SEALS

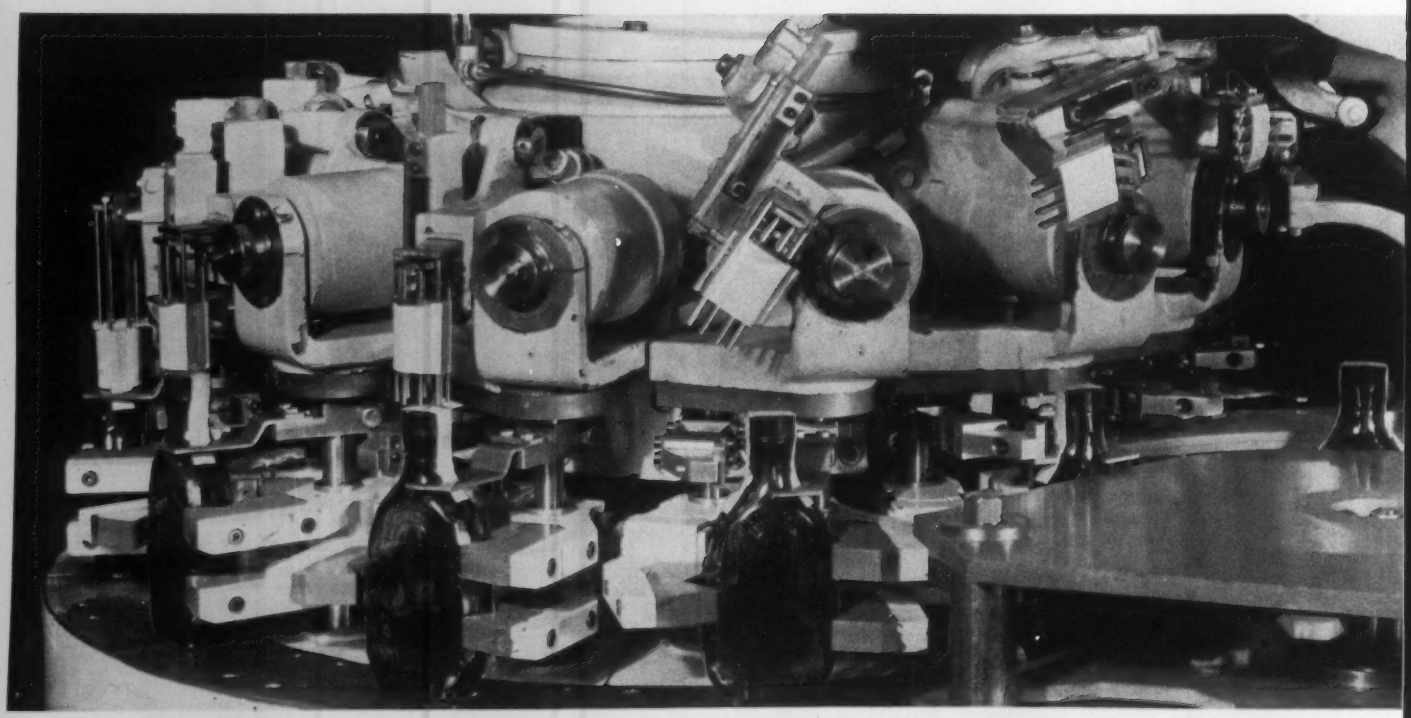


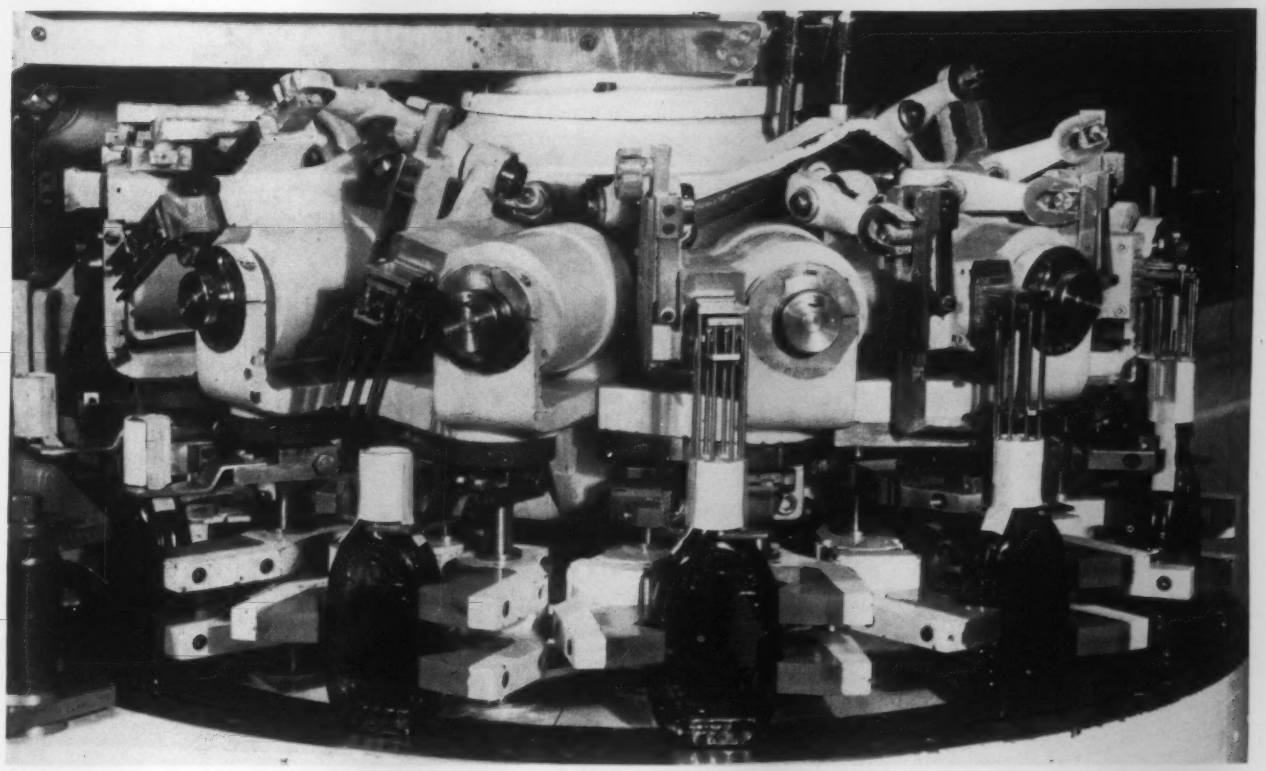
8

Left—As the 12-station turret rotates, each head turns down 90 degrees and the eight fingers expand within the seal. The bottles are spaced out by the metering wheel and guided off the conveyor into a work station under the eight-finger head turret.

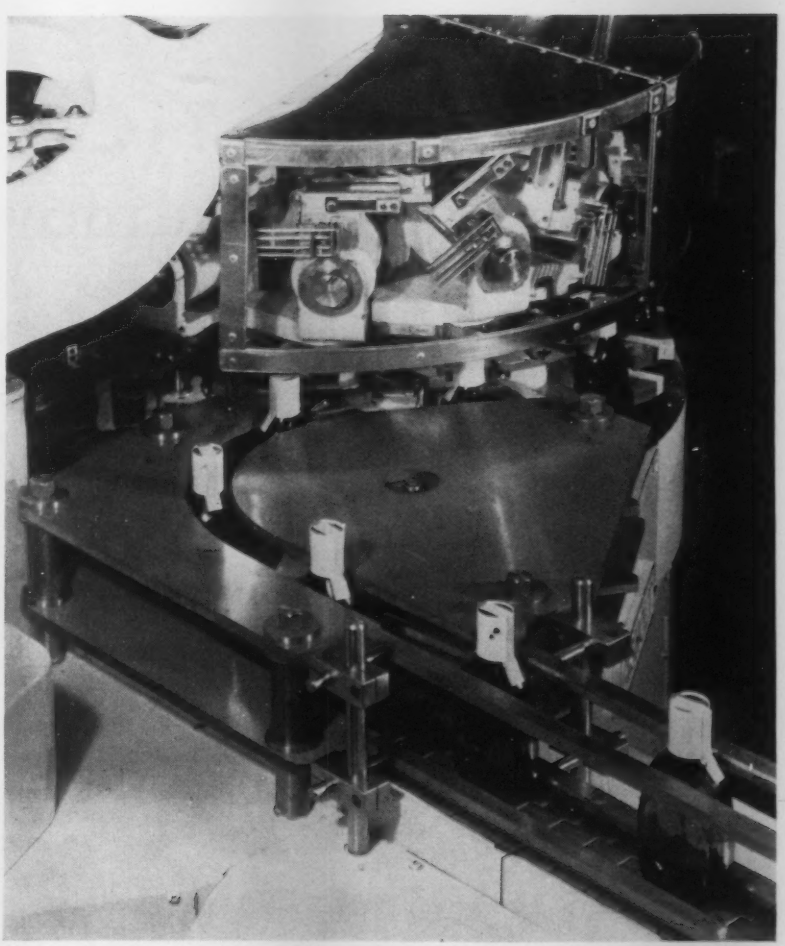
9

Below—Seal is swung into position above the bottle and cam actuated stripper slides it off the eight-finger head down around the bottle neck, as turret and bottles progress around rotary table.





10 Having delivered the seal the stripper retracts; the eight-finger head collapses as it turns back up to position to receive another seal from the two-finger head.



11 Completion of the operation is accomplished when the bottles are moved back on the flat top chain conveyor; seals will dry out and shrink tight as they move on to the next operation.

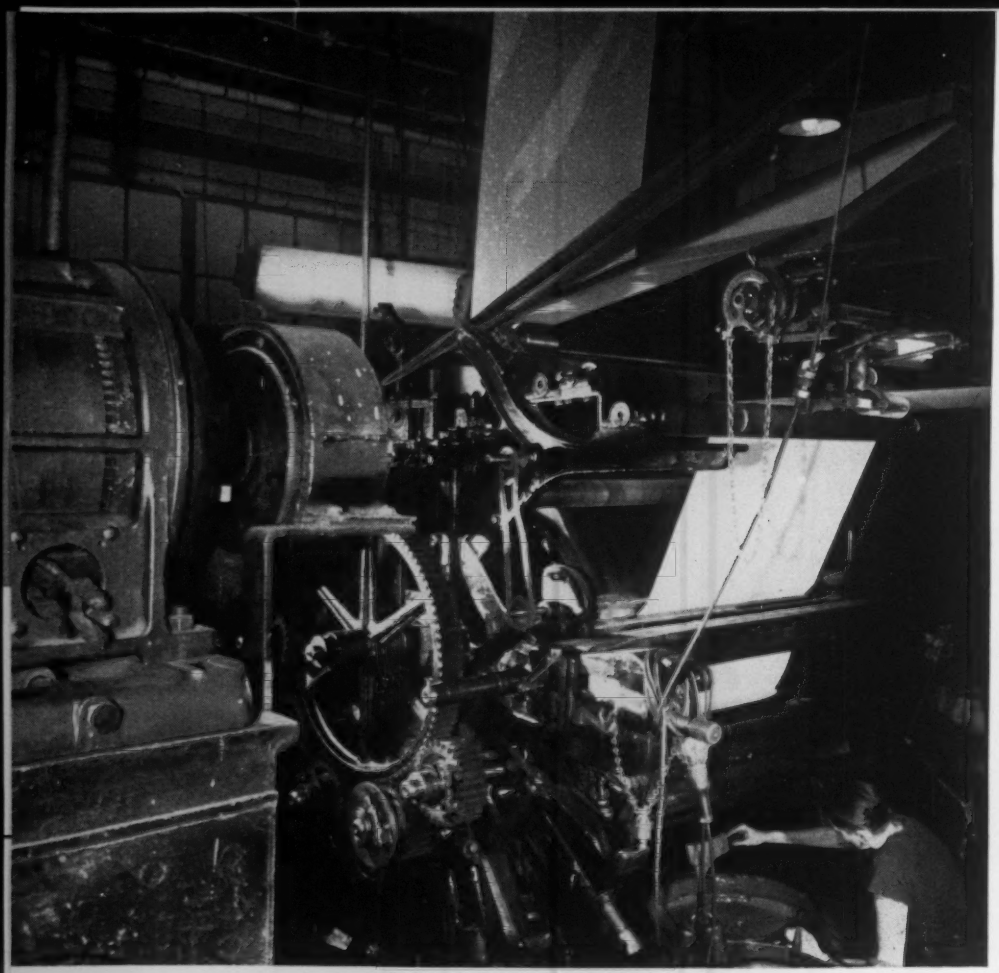


Fig. 1—Large press used by Pontiac Div. of Fruit-of-the-Loom Inc. to print cloth. Cloth from press goes up to floor above after being printed. Endless rubber belt which holds cloth against printing rolls runs out of the press toward top right to washer which removes all ink and rinses the belt before it returns from right center (cleaned) to machine

PNEUMATIC TIME DELAY

FOR AFTER SHUTDOWN PROTECTION

Many systems require operation of an auxiliary protective device after the operating cycle is stopped. This relay operates a rinse to remove dye solvent from the belt of a textile printing unit

WHEN A CONTINUOUS belt passes through a series of process stations, effects on the belt must be considered at each station after shutdown. If one station introduces a damaging element to the belt, a succeeding station can remove it but does not give shutdown protection.

A simple, inexpensive control system which automatically starts or continues operation of a machine auxiliary, after the machine itself has stopped, was developed by Dewey & Almy Chemical Co. to provide an automatic rinse for fabric printing machines. Textiles are printed by running rolls of cloth over revolving printing rolls, in much the same manner as newspapers are printed. Cloth is supported and kept in contact with printing rolls by an endless belt or blanket. Conventional practice is to run an extra roll of cloth, a "back gray", between blanket and cloth being printed. Back grays prevent blurring and smearing by absorbing

excess dye forced through the cloth being printed.

Using back grays is expensive, since they must be removed from the printing machine to be washed prior to being rerun, and are not usable after a few cycles of operation. The Darex blanket process, *Fig.* 1, makes obsolete the practice of using back grays, since the blanket itself absorbs excess surface dye. A continuous washing process was introduced to remove dye picked up by the endless belt before it returned to the printing roll section. The belt is run through a two-section washing machine—a section where solvent removes dye from its surface, and a water rinse section.

Protection Needed

When the printing machine and washer are stopped simultaneously, there is a small belt section which has passed through the solvent washer section but not yet reached the rinse. This was not a problem until recently when new latex dyes were introduced, necessitating a stronger solvent that could seriously damage belt surfaces if not rinsed off promptly.

An auxiliary spray for the blanket in the area between solvent and rinse sections solved the problem. A control device is arranged to turn this spray on only when printing machine and washer stop, and remain on for a predetermined period. It was decided not to do this manually as a machine operator might forget or not be present when an unexpected machine stoppage occurred—circumstances which might ruin a valuable blanket.

Delay System

Complicated control setup was avoided through use of an Agastat time delay relay, manufactured by the AGA Div., Elastic Stop Nut Corp. of America. This relay, shown schematically in *Fig.* 2, has two sets of contacts—main and auxiliary. When the solenoid coil is energized its core is pulled down, transferring both sets of contacts. When the coil is de-energized, the core tends to return to its previous position, but motion of a diaphragm to which the core is attached is delayed by flow of air through an adjustable restriction. Linkage of contacts to the core is arranged so that the slightest

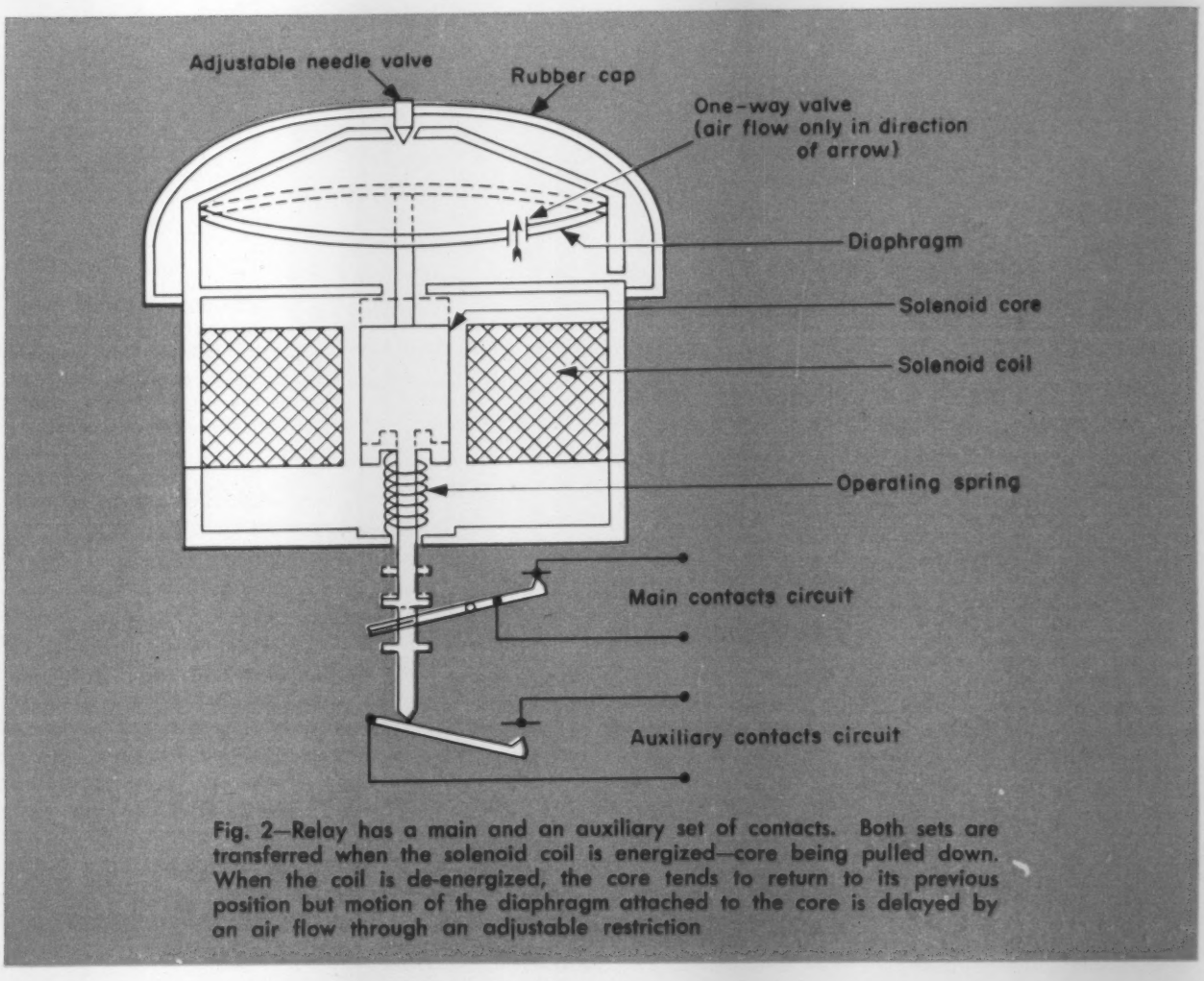


Fig. 2—Relay has a main and an auxiliary set of contacts. Both sets are transferred when the solenoid coil is energized—core being pulled down. When the coil is de-energized, the core tends to return to its previous position but motion of the diaphragm attached to the core is delayed by an air flow through an adjustable restriction

return motion transfers the auxiliary contacts back to normal, but full return of the core is required before the main contacts transfer again. Thus, an adjustable time delay takes place before the main contacts return to their previous position.

Schematic sketches, *Fig.* 3, illustrate the valve control cycle. When printing and washing machines are not operating, although the auxiliary contacts of the time delay relay are normally closed, there is no water rinse spray because main contacts are normally open. When the printing and washing machines are started, the time delay relay coil is energized and both sets of contacts immediately reverse—no rinse water flows since main contacts have closed, auxiliary contacts have opened.

When power to the printing and washing units is cut off, the relay coil is de-energized, auxiliary contacts promptly close, and time delay begins. During the adjustable delay period of from 0.1 seconds to 5 minutes, both sets of contacts are closed, opening the solenoid valve for rinse water to flow. At expiration of the time delay period, main contacts open and flow of rinse water stops, completing a cycle.

Major advantage of the pneumatic type time delay relay for this application is that time delay begins upon de-energization. The device need not complete its time delay period before resetting to start another time delay. This is important as it provides full water volume delivery regardless of how soon the machine is stopped following a start. Situation occurs during jogging of the machine when a new roll of cloth is being aligned, and may occur if low voltage or overloads were to kick motor starters out soon after starting.

In other applications, various auxiliaries can be substituted in place of the solenoid valve in this particular system. Examples are ventilation blowers, coolant pumps, conveyors, indicating lamps, or an alternate machine in an automated setup. Circuits can be arranged so that the auxiliary operates while the main machine is operating and for a specified period after it is shut off, or to operate only for a period after it is shut down.

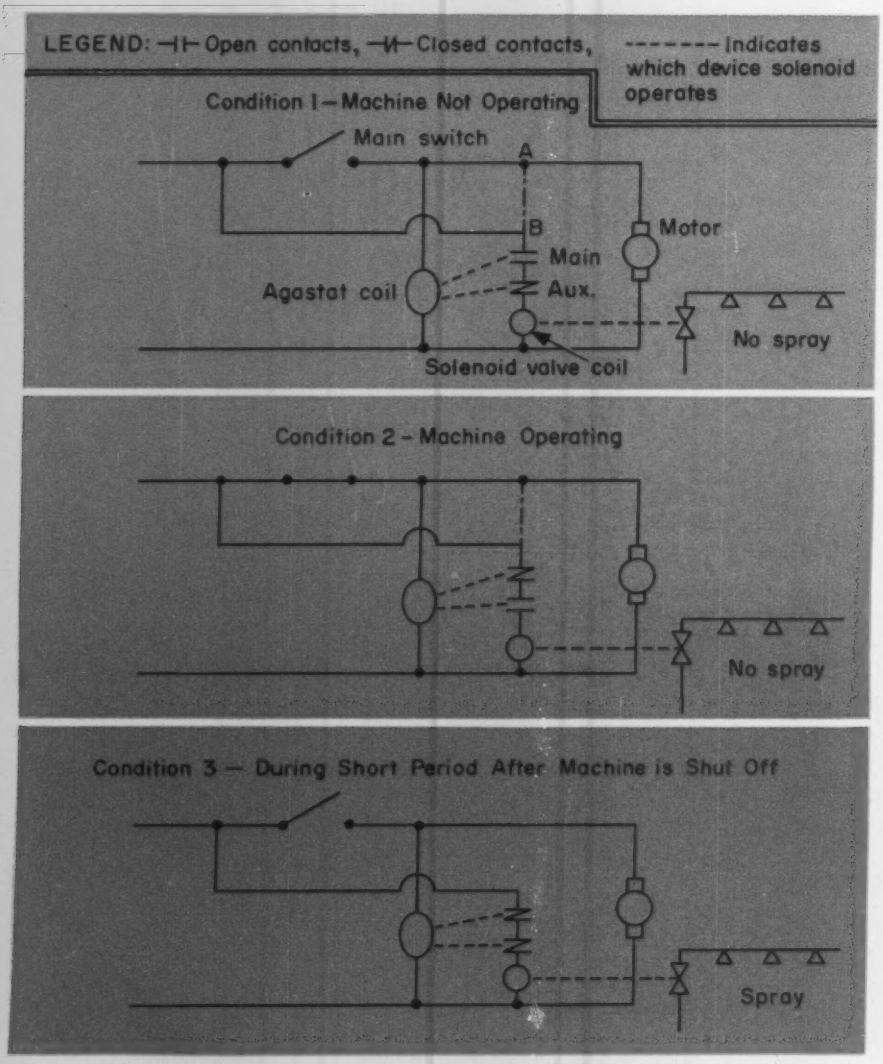


Fig. 3—Schematic drawing showing cyclic operation of machine auxiliary. Dotted lines indicate the contacts operated by motion of the solenoid core. Note that both the main and auxiliary contacts are in the solenoid valve circuit. Valve is open only when both sets of contacts are closed

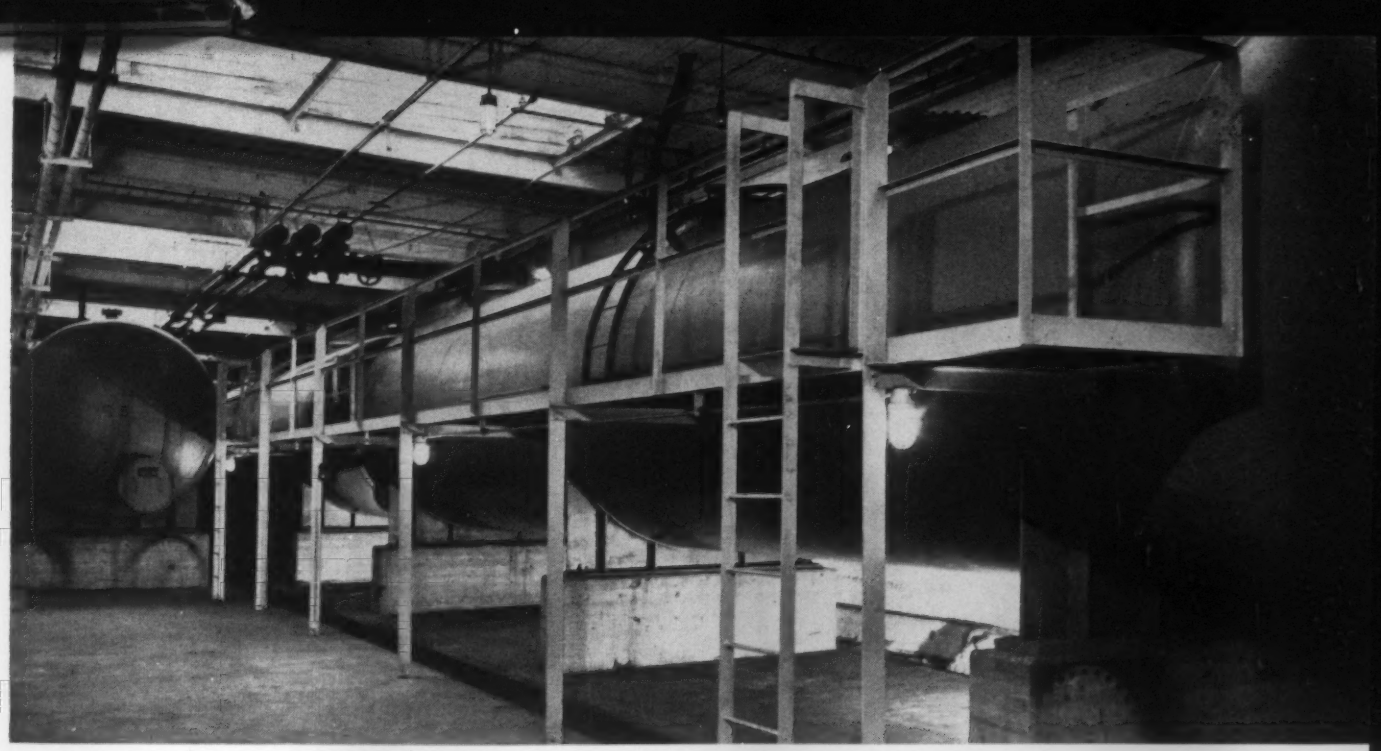


Fig. 1—Latex storage tanks form a 100,000-gallon reservoir for the automatic foam plant

LATEX TO FOAM RUBBER
AUTOMATICALLY

You are invited to "tour" an automatic foam rubber products plant in these pages. Higher efficiency, lower costs, and improved products are obtained along with operational versatility. Great competitive advantage favors materials and designs adaptable to automation

By LEONARD J. BISHOP
Vice President, Engineering
Mechanical Handling Systems, Inc.
Detroit, Mich.

AUTOMATION is often thought of in terms of plans or even dreams; here is reality.

Most consumers can remember when foam rubber was a luxury item. Gradually, as improved production methods gave manufacturers more capacity and lower unit costs, foam became competitive with traditional materials such as feathers, down, hair and springs. More recently, in the Dunlop Tire and Rubber Corp. Buffalo plant, the production rate jumped from 8.1 mattresses per worker per shift to 96 mattresses. How? Automation.

Latex, both natural and synthetic, arrives at the Dunlop plant, designed and built by Mechanical Handling Systems Inc., in tank cars. Compressed air forces the white liquid through one of three separate pipeline systems into the proper 20,000 gallon storage tank, *Fig.* 1. Since even natural latices may differ depending upon the part of the world they come from, multipipes are necessary to prevent contamination and simplify maintenance. Each tank contains agitating equipment to keep solids in suspension since latex will separate much as cream rises in whole milk if left at rest.

From the storage tanks, various grades of latex are pumped to the compounding tanks inside the plant, *Fig.* 2, each acting like a giant churn to thoroughly mix ingredients. Tank jackets contain networks of pipes for hot and cold water to attain and maintain required temperatures for various stages of the processing, *Fig.* 3. For example, to remove the ammonia—added to natural latex at the plantation as a preservative—latex is heated in

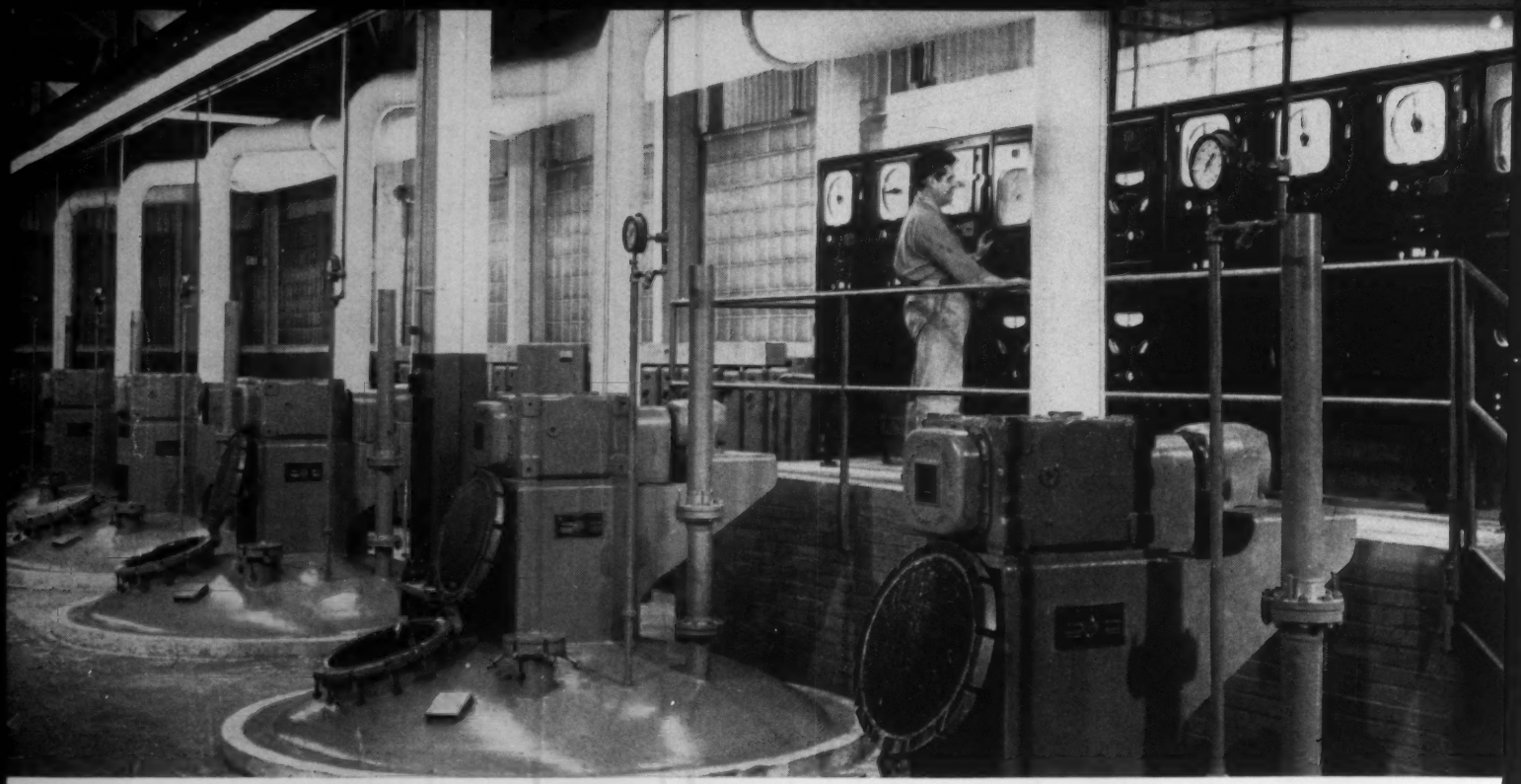


Fig. 2—Battery of six compounding tanks where latex mixture is prepared. Temperatures are controlled at panel by adjusting hot and cold water flow in tank jackets

the tank to an exact 100F. A stream of air across the surface of the liquid carries off vaporized, excess ammonia.

▶ Mixing the Foam

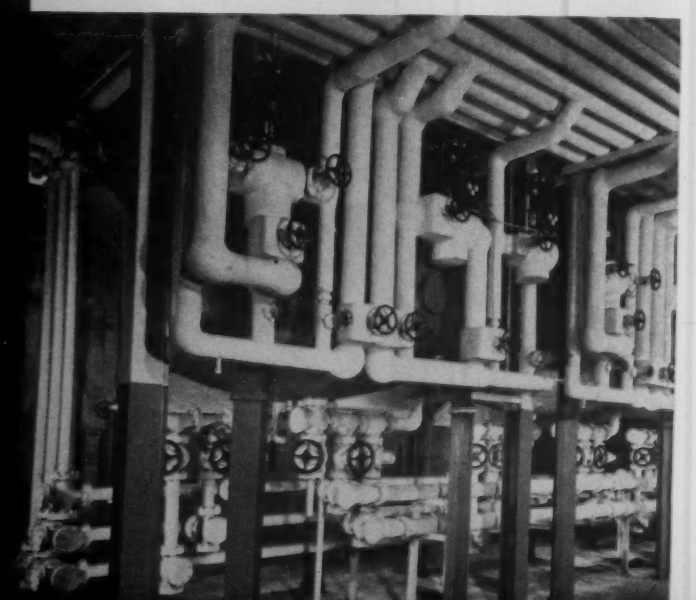
A single man handles all compounding room operations. He controls the charging of a battery of ball mills, *Fig.* 4, that grinds dry ingredients and prepares aqueous dispersions of the vulcanizing agent, activators, accelerators, antioxidants and gelling agents, and also controls preparation of other ingredients in slurry tanks. Automatic equipment helps assure accuracy in compounding, a procedure necessary in maintaining continuous uniformity of product.

From the ball mills and slurry tanks, mixtures are blown to storage tanks where dispersions are agitated to maintain uniform suspension of finely ground particles in the liquids. Softening equipment conditions water for use in dispersions as shown in *Fig.* 5.

To gather ingredients from the tanks, a system was devised that allows collection of exact quantities, provides a permanent record of all those quantities and relieves the operator of all lifting. A traveling, self-propelled scale car, *Fig.* 6, can move up and down the aisle, and laterally to the tanks. The car container can be brought into position under the nozzle of any one of the dispersion tanks. The operator draws off the correct amount of the mixture by weight which is recorded on a print-weigh mechanism. He then moves the loaded scale car to the appropriate compounding tank, and by opening the valve at the bottom of the container, allows the contents to run into the compounding tank.

After all ingredients are added to the latex in the compounding churn, the mixture is allowed to mature for at least 24 hours. Circulating refrigerated water through the jacket stops maturing action and the latex is ready to be converted into foam. The mixture is piped to a 500-gallon, auto-

Fig. 3—Lower portions of compounding tanks showing three-pipe system. Each tank has 4000-gallon capacity



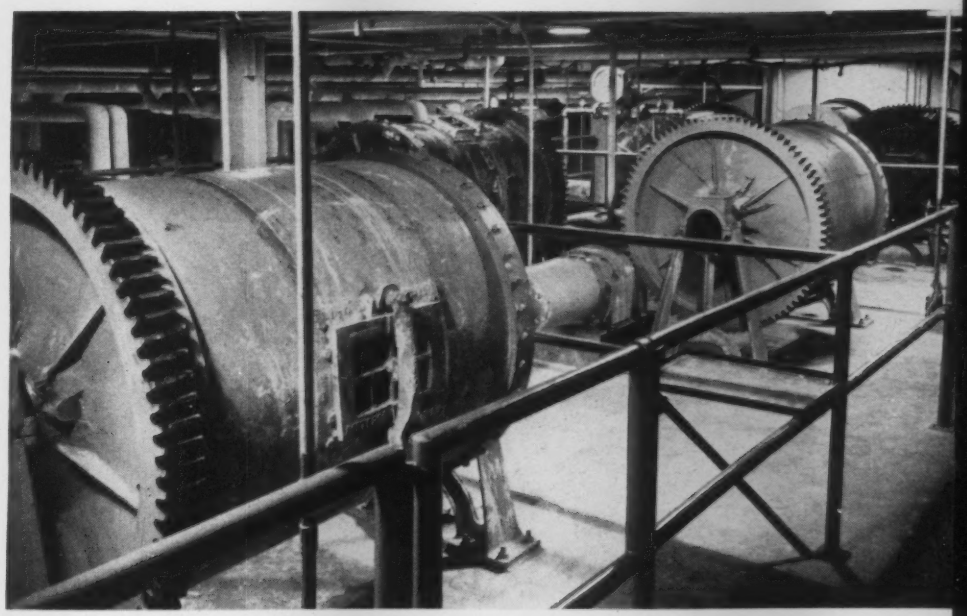


Fig. 4—Dry ingredients are loaded into these ball mills through trap doors in compounding room floor

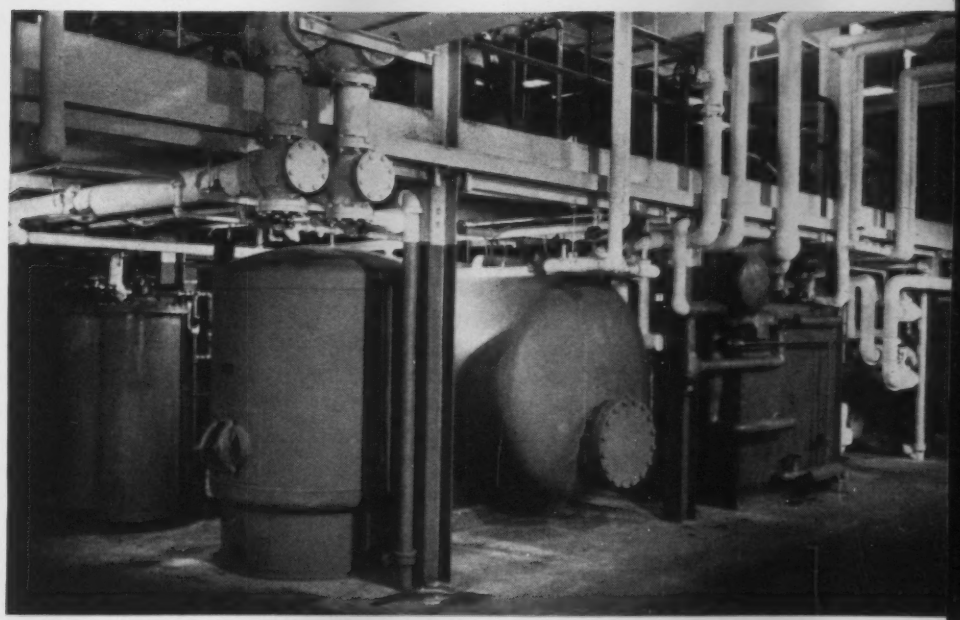


Fig. 5—Equipment used to condition water for the compounding process. Ball mills are above

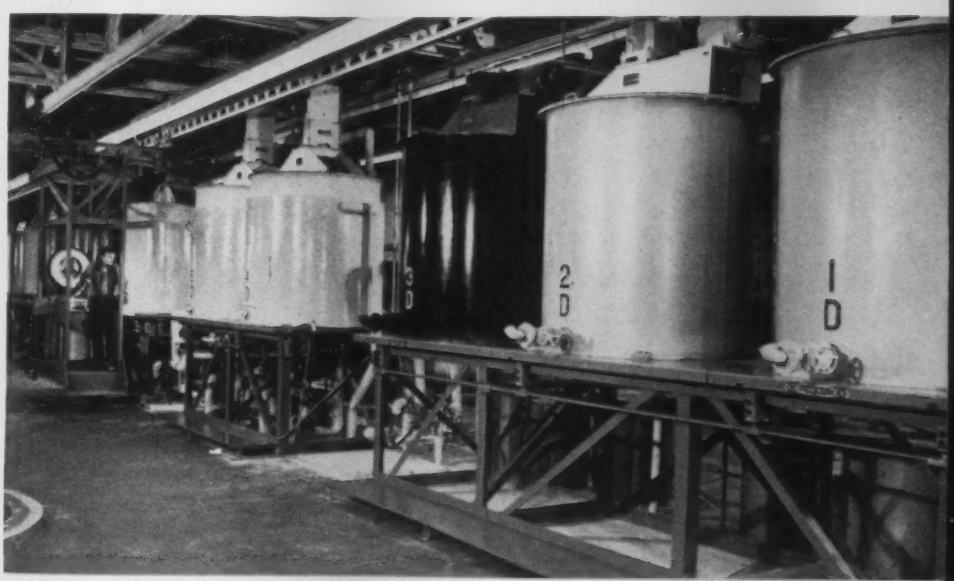


Fig. 6—Operator draws required amounts from dispersion tanks. Scale records weights automatically as the car carries ingredients to compounding tanks

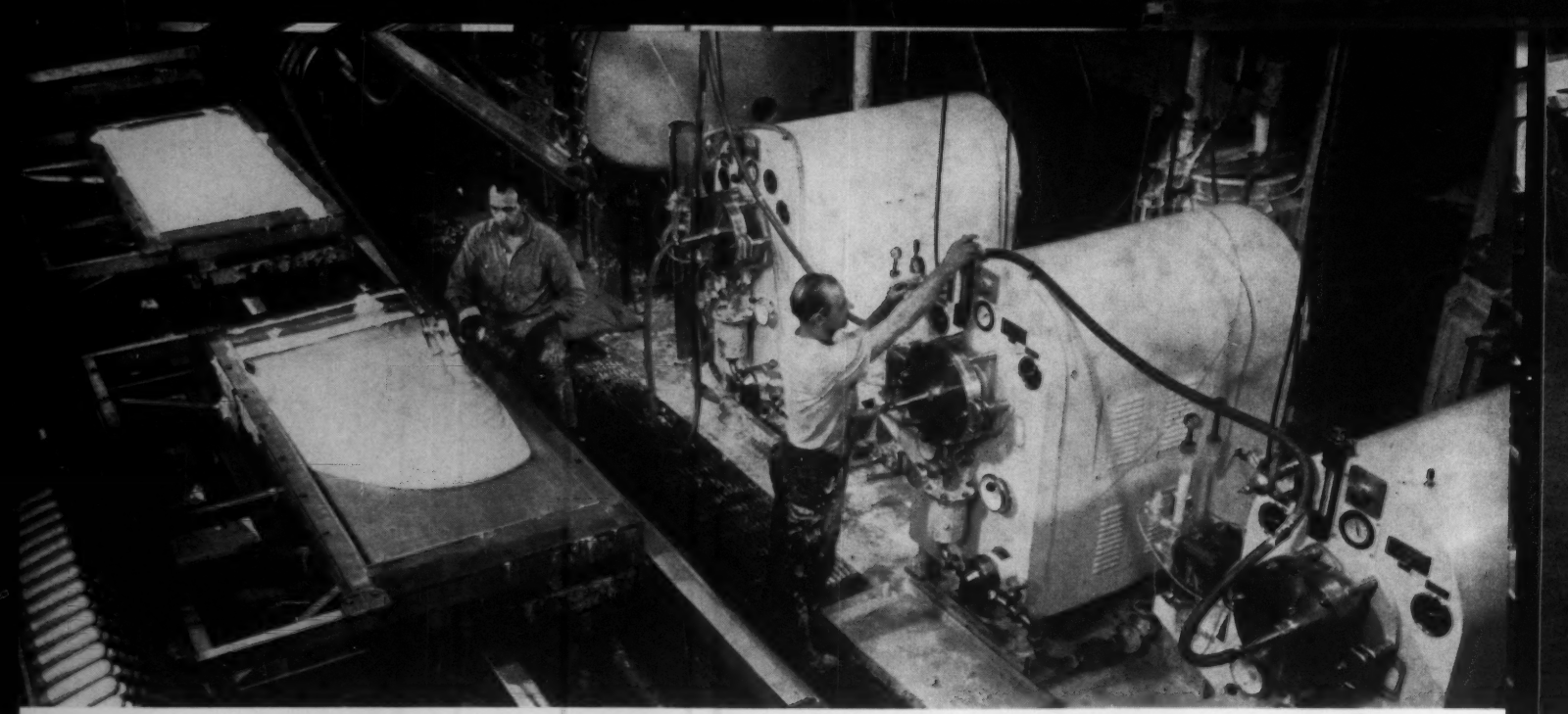
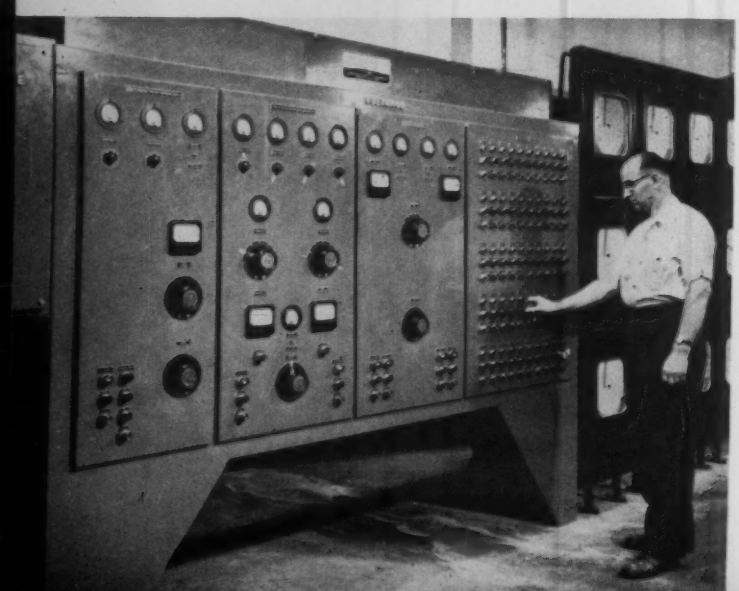


Fig. 7—Foaming machines inject air into latex mixture. Molds are filled as they pass pouring station on conveyor. Mold lids close automatically

matic float-controlled tank for temperature adjustment, then flows to the continuous mixers that inject air and break up large bubbles. Here, also, two more ingredients are metered into the mixture —one causes the latex to gel later, and the other is a chemical activator needed for vulcanizing.

The second man in the process constantly checks foam density determining firmness of the final product. Also, high density makes a great difference in the profit column. Latex foam is discharged from the mixer through a hose used for filling molds by the third man in the operation, *Fig.* 7. White and fluffy, the foam looks much like whipped cream.

Fig. 9—Controls for process mechanisms and temperatures are located on this panel



Pouring a Mattress

A loop conveyor with 45 pallets carries molds past the pouring station. In filling, the operator levels the latex foam to uniform height, carrying excess to the next mold. Mold lids are open as they approach the filling position and close automatically as the pallet moves away, *Fig.* 8. The gelling agent sets up the foam as the conveyor takes the mold toward the vulcanizing chamber at a temperature of 85F. When poured, molds must remain at this temperature for 8 minutes for proper gelling.

Time in the vulcanizing chamber is critical, too, and automatic controls maintain preset conditions, *Fig.* 9. The specially designed vulcanizing or curing chamber is heated to 210F by steam. Molds are raised to the top of this chamber where steam is at its highest uniform temperature, and continue through this zone until curing is complete. Chamber design prevents steam from escaping into the room, and steam costs only 2 to 3 cents per mold.

After the mold emerges from the curing chamber, the lid rises automatically Fourth and fifth men in the process strip the cured product from its mold and place it on a belt conveyor. At this point it is wet and hot, and must be washed and dried—automatically. Meanwhile, the stripped mold passes through a cooling water spray, a drying air blast and a lubricant spray for easy stripping. Then it passes through a chamber that brings the mold back to the proper temperature for pouring again.

The belt conveyor, carrying the cured product to the washing machine, uses overhead space in a belt system that makes a 180-degree bend, travels

Fig. 8—After lids automatically close, molds enter vulcanizing chamber

up an incline and down into the washer where free chemicals remaining in the foam are removed by hot-water washing and wringer rolls, *Fig.* 10. Removal of all curing chemicals insures an odorless product.

Sixth man in the production setup transfers the product to the drying oven, *Fig.* 11. The operator must place the product on the conveyor without the slightest distortion, to avoid permanent set by the drying process.

▶ Finish and Inspection

Temperature at the start of the 200-foot long oven is 260F, decreasing to 200 degrees at the end of the oven. The product emerges into a cooling chamber completely dry. After cooling, work is deposited on a trimming conveyor, *Fig.* 12, except on the midnight shift when placed on a storage conveyor, necessary because state law doesn't allow women to work on the midnight to morning shift.

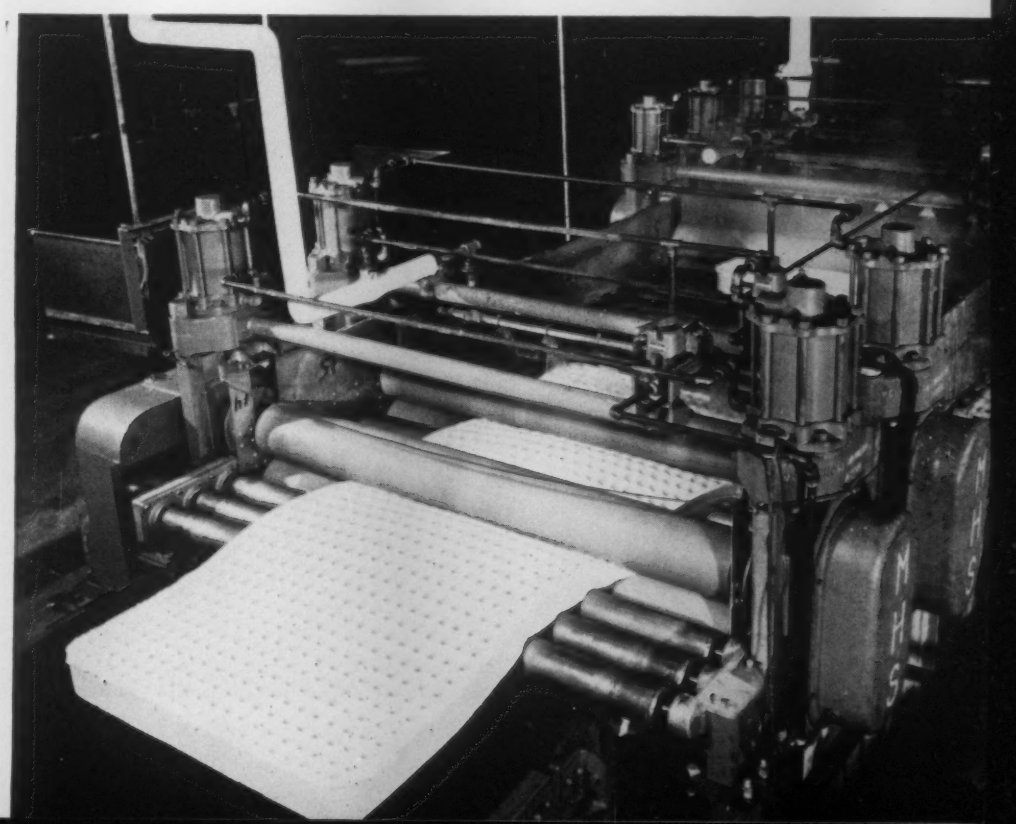


Fig. 10 — Washing machine needed to deodorize the product. Wringers squeeze water out and pass molded foam pieces onto another belt

Trimming, inspection and finishing operations are shut down during that time. On day and afternoon shifts, stored production is worked into the flow through the finishing stations.

Traveling by conveyor through the finishing department, flash is trimmed from sides and corners. Density is checked automatically by a compression test, *Fig.* 13, and visual inspection is made. Operators cement together pillow halves and mattress sections. Comparison of incoming raw material weight against weight of the finished product furnishes a continuous and accurate check of overall plant efficiency. On a special section of the conveyor, each product is weighed and the weight recorded without disrupting the flow of work, *Fig.* 14.

When a mattress, pillow or pad rolls onto this section, it breaks a light beam to an electric eye and starts a sequence of events. The conveyor at the scale position drops, leaving the product on the cage-like scale platform. As the section drops, the live roller turn behind the weighing station is stopped to keep the next product from following.

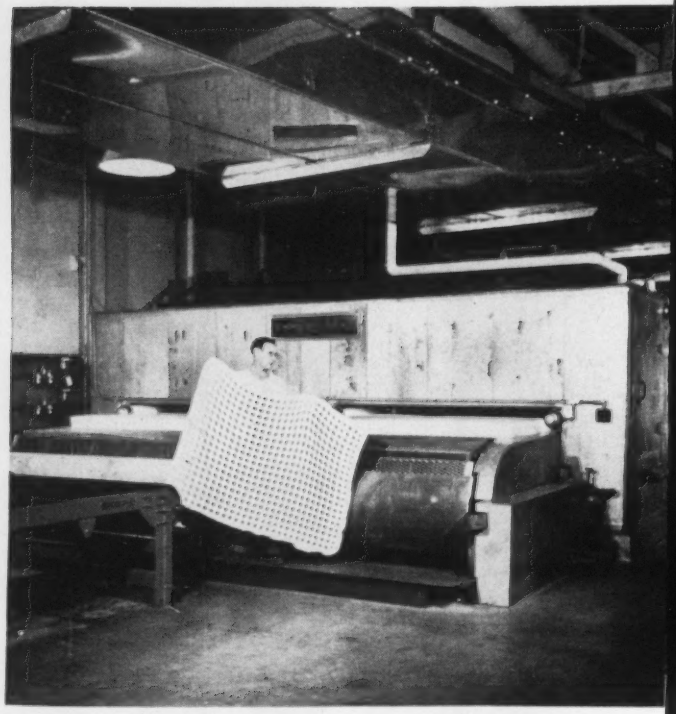
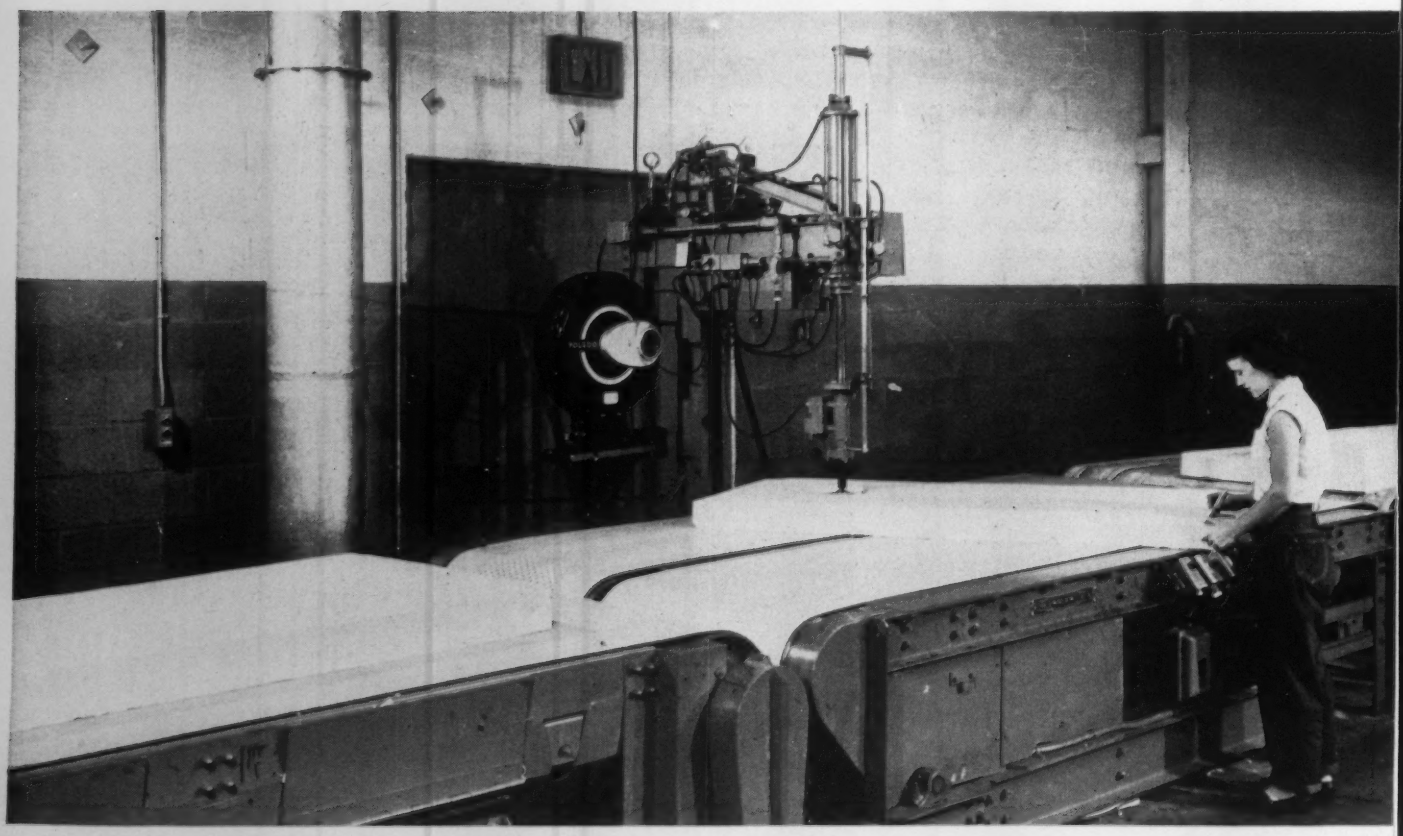


Fig. 11—Manual placing of mattress on drying oven conveyor is necessary because its soggy condition makes mechanical handling difficult. Piece must lie flat for curing

Fig. 13—Firmness measurement and visual check are made at this station



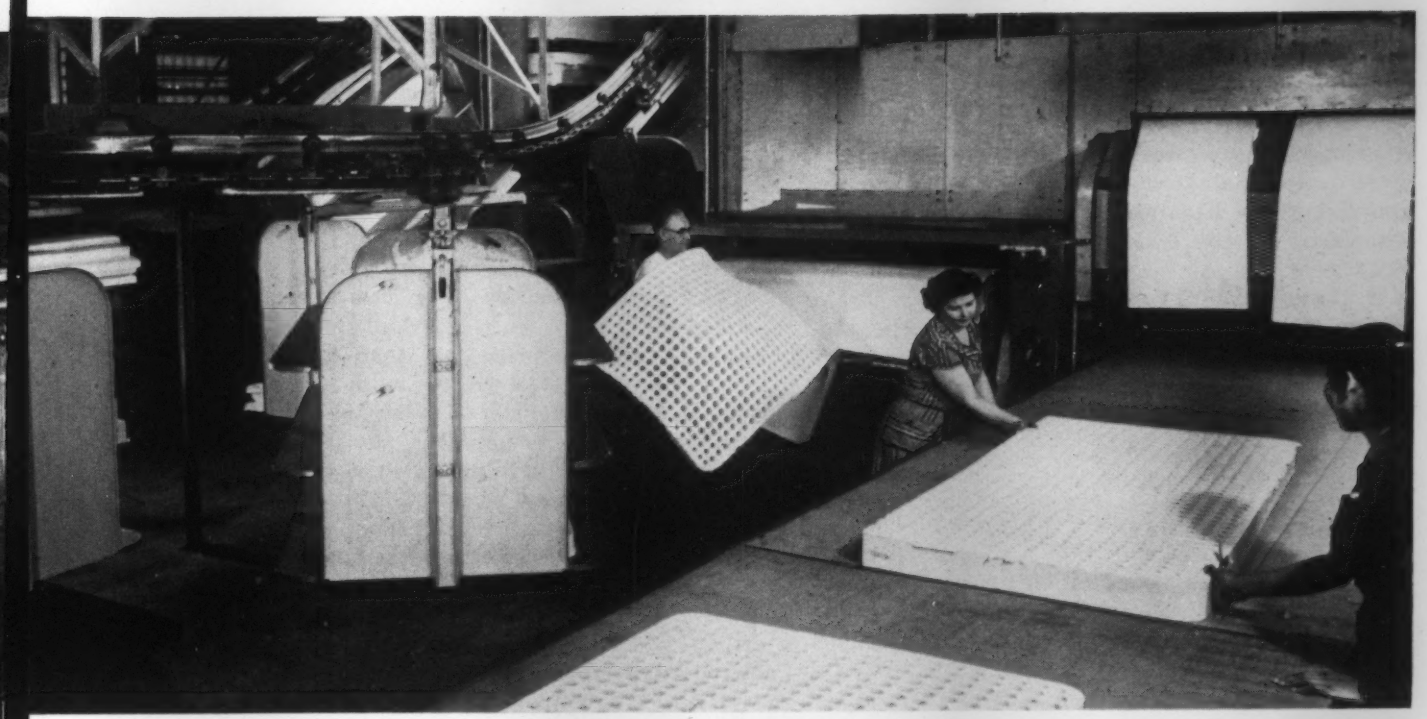
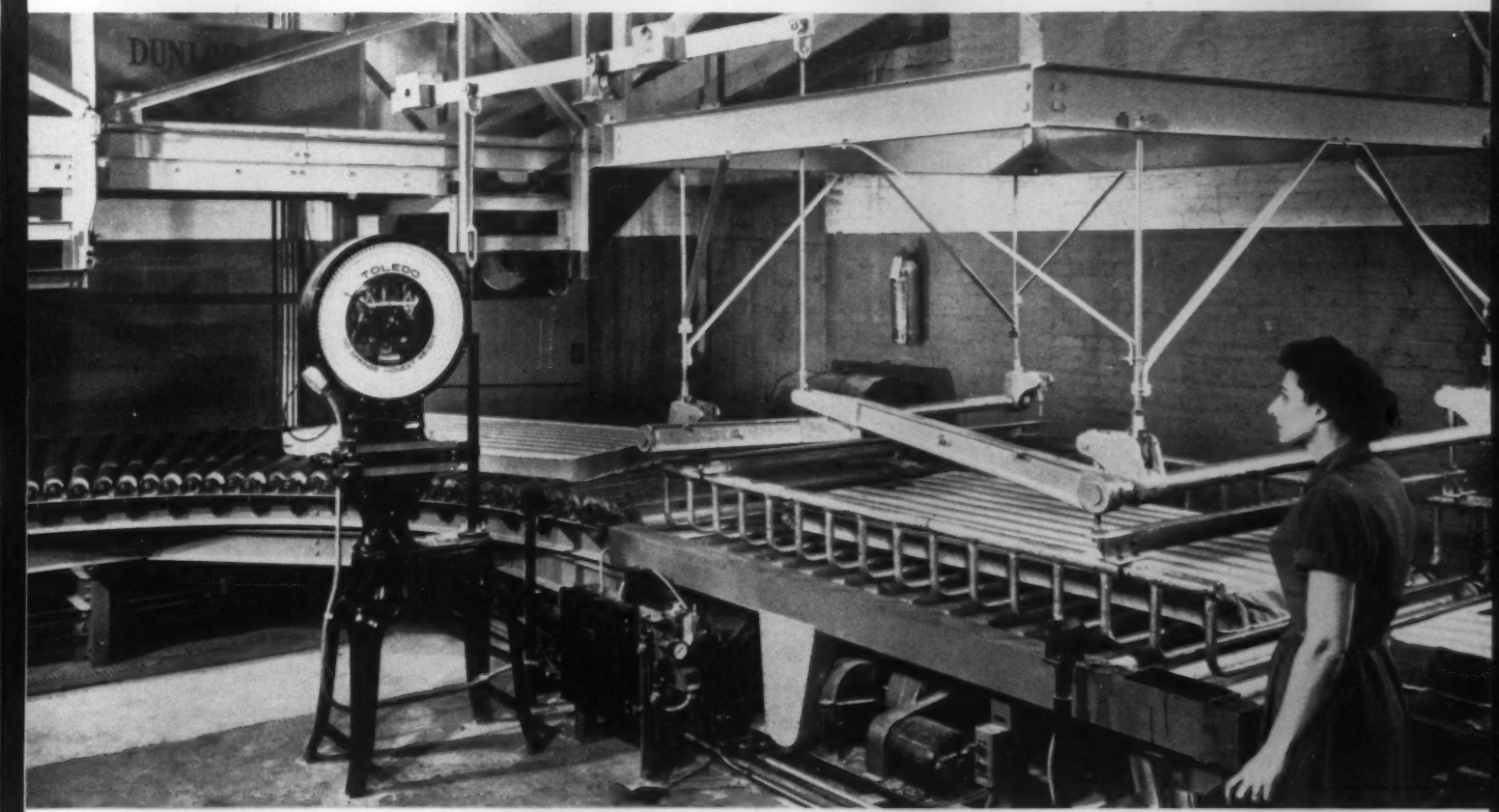


Fig. 12—After passing through the curing oven, flash is removed in the finishing department. Rack conveyor takes midnight-shift production which is trimmed on the other shifts

Fig. 14—After finishing, mattresses are automatically weighed. Some customers supply covers for mattresses ordered



A printing mechanism records the weight of the piece on the scale, the roller section rises and begins to turn, and the weighed product moves along —replaced on the scale with the next, all automatic.

If the customer's order requires it, the foam rubber products receive a covering. In packaging, prefabricated cartons are used to speed the operation. An inclined belt, *Fig.* 15, takes filled cartons to the warehouse for storage or direct shipment by truck or rail.

Overall Benefits

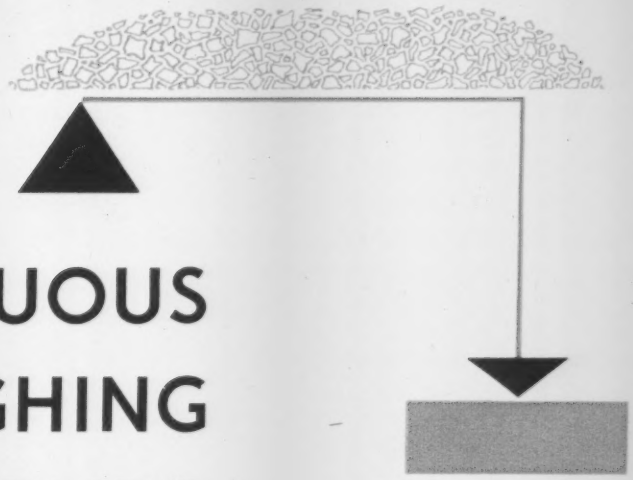
Total work force, including all hourly employees on all shifts, is only 35 people. Mechanization and automatic controls make high production possible. Routine maintenance is largely automatic, too. On the main pouring and curing conveyor there is automatic lubrication while the equipment is in operation. Continuous oil flow bathes the main drive, which, in addition to lubricating, removes water resulting from steam condensation. The oil-water mixture is collected in a tank, separated and water drawn off.

Correct tension on the main chain of this conveyor is maintained by an air cylinder on the driving mechanism. In case of air pressure failure the whole line is shut down automatically. If for any reason a mold lid fails to close before entering the curing chamber an electronic safety device stops the line.

Critics of automation often complain about its lack of versatility. In this case, however, we have designed the equipment so that molds can be changed at will—even without stopping production, if necessary. While the 45 pallets on the conveyor provide adequate variety for normal production, the interchangeability feature adds to plant versatility, both in design variety and in quantity fluctuations for any particular product.

Through application of most advanced automatic production techniques, everyone concerned has benefited. The company benefits from greater efficiency, lower costs, greater productivity per man hour, improved product and improved competitive position. The employee benefits from less tedious and fatiguing work, more pleasant working conditions and the probability of steady employment. The consumer benefits from uniform high quality, and a lower price trend.

Fig. 15—Products are individually boxed in the shipping department and moved by conveyor to the warehouse



CONTINUOUS WEIGHING OF SOLIDS

Attainment of accurate continuous weighing offers a degree of automatic control with solids processing comparable to that common with fluids

By ROBERT H. BERG
Process Control Services Co.
Elmhurst, Ill.

INCREASING USE of continuous processing for solids brings out many problems in measurement and control. Of prime importance are problems in flow rate and level measurement. Applications of automatic measurement and control equipment, are difficult due largely to the handling properties of solids. Measuring and controlling elements in contact with solid process materials are characteristically subject to relatively severe conditions of build-up and abrasion.

Solids can be defined as materials ranging from heavy, nonpumpable slurries to bone-dry substances, with particle sizes ranging from dust to coarse gravel. Problems are especially difficult when the materials are sticky or cannot be kept flowing readily, and it is unfortunate when process requirements call for such materials. Flow rate measure and control are essential to maintaining proper ratios between chemically reacting substances or ingredients of compounded mixtures and to hold constant the processing or equipment feeding rates. Keeping the process inventories within permissible limits at various points of accumulation is likewise essential, to accommodate such situations as an intermittent supply of raw materials or a recycling load around one section of the process. Maintaining control of these *quantitative* variables in continuous processing eliminates many difficulties and disturbances in the control of qualitative variables such as temperature, pH, pressure, density, etc.

Based on a paper presented at the Eighth Annual ASME Instrument Conference, Chicago, September 1953.

This discussion is limited to the measurement aspects of solids flow rate and inventory control, as the factors involved in measurement are numerous enough and are appropriately treated as an integrated topic. Controllers and control elements are dependent upon effective measurement and involve another group of factors.

Continuous Weighing as a Measurement

Continuous weighing is generally the most feasible means for quantitative measurements of solids and has the advantage of providing accurate measurement without inherently placing the measureing elements in direct contact with the process materials. Solids flow and level admit of no convenient phenomenon comparable to fluid orifice effects or self-seeking levels although, as finely divided solids are brought to an increasingly fluidized state, these phenomena may be approached.

To a limited extent, solids flow rate may be measured volumetrically, under appropriate circumstances. A bucket wheel, conveyor or helical vane hung in a solid-filled vertical duct will produce a rotational speed signal as the material passes through the duct. Errors are resultant, however, when the bulk density changes and build-up due to direct contact with the process material can be a problem. Most often, continuous weighing of a section of constant-speed belt conveyor is the effective means for measuring solids flow rate, *Fig.* 1.

Bin and hopper levels are often measured by

mounting pressure-actuated switches in the walls or by inserting probes tipped with special electrical capacitors, audio-range vibrators, or moving paddles (arrested when covered with solids). Again, build-up problem from direct material contact can occur. Also, such units provide little more than single-point level measurement vertically and laterally, and many units must be used to approach continuous, quantitative, accurate knowledge of solids level. Continuous weighing of the hopper and contents provides such knowledge, and is quite practical in many instances. For weights over 20 to 30 tons, higher structural costs must often be rationalized with the value of this type of measurement.

At the point of measurement, weight may be sensed and translated into various types of signals: mechanical, pneumatic, hydraulic, or electrical. This is comparable to the measurement of orifice differentials or tank levels by mechanical, pneumatic or electrical instruments. Continuous weighing characteristics of the several basic types of weight-measuring elements are as follows:

1. *Mechanical* scales are old familiar instruments employing lever systems to measure directly by weight balance. Such lever systems are used to some degree in other forms of weighing to bring the desired force to bear at the point of measurement. The inertia and rebalancing momentum of mechanical scales accounts for a relatively slow response in continuous weighing, compared to the other types. Also, signal transmission any appreciable distance is limited to cumbersome linkages or signal conversion devices.
2. *Pneumatic or hydraulic* weighing utilizes a force balance of air or liquid pressure on a diaphragm, piston or bellows, which permits ready standardization of signal range through appropriate selection of pressure-balance areas. The typical unit has low inertia and a simple, completely enclosed construction, providing fast response and few maintenance requirements. There is, however, still an appreciable time lag in signal transmission (less in hydraulic) as compared to electrical weighing elements.
3. *Electrical* weighing is accomplished by the resistance strain gage principle or by a similar one which utilizes an inductance change with micromovement of a strained metal bar. Response and signal transmission are extremely fast, and the elements are well protected by complete enclosure. There is no general standardization of signal ranges, however, and temperature compensation must be considered.

The type of primary sensing element appropriate for any given installation depends on the response requirements for the transmission distance involved, the measuring range, and the adaptability to desired secondary instruments. Also, consideration must be given to particular features or available manufactured models, such as overrange protection and space requirements. Which type of sensing element is used does not, however, materially affect the general design factors of the flow rate or level measurement installation.

A typical conveyor flowmeter in which a section

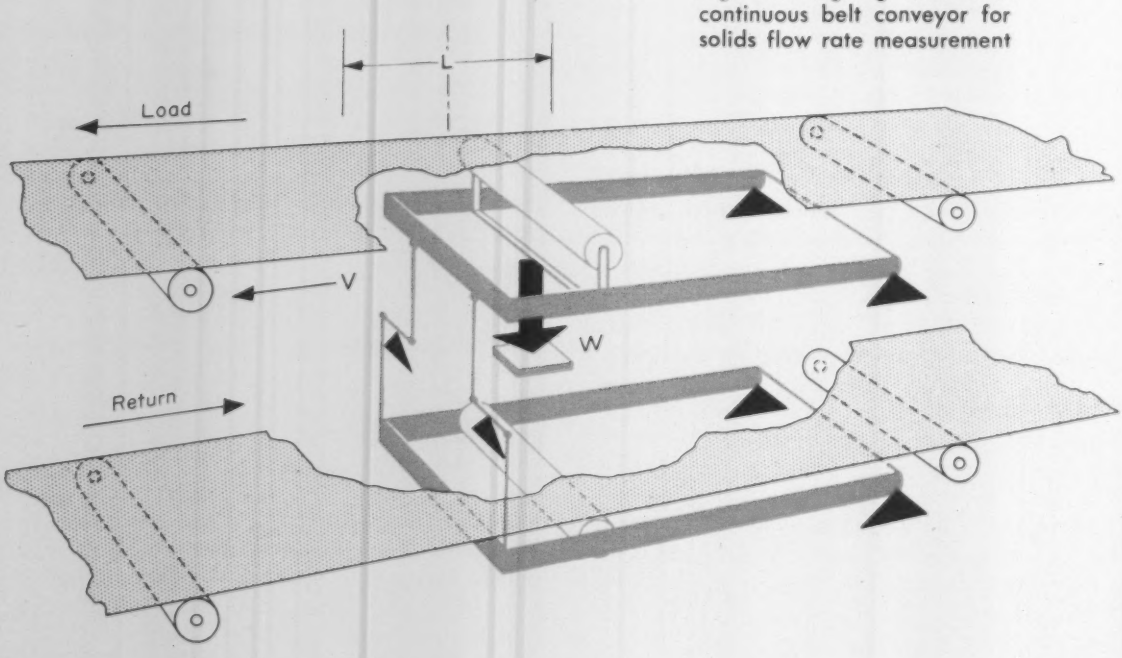


Fig. 1—Weighing section in continuous belt conveyor for solids flow rate measurement

of the conveyor belt is weighed on both the load-carrying and return sides is shown in *Fig.* 1. Through the counterbalancing levers, the return span effectively tares the load-carrying span, also providing compensation for belt weight variation and material adhering to the return belt. The net load is weighed directly at the load-carrying span by any of the several types of weight measuring units.

Designs vary in the number of idler rollers in the weight-span (one or two) and the lever-fulcrum arrangement about the point of measurement. Also, alternate methods of taring are used, such as separately weighing the return span and subtracting its weight signal from that of the load-carrying span, or assuming a fixed tare and weighing only the load-carrying span. However, the conveyor flowmeter shown is direct and simple in principle and permits ready illustration of all pertinent factors.

A major variation, in which the entire conveyor is weighed, is illustrated in *Fig.* 2. The small size of the conveyor is especially useful where space allowances are close, and moving the material any distance is of little or no importance. The tare must be of the fixed type, and includes the belt drive when the motor is mounted on the conveyor framework to avoid varying torque effects.

In either case, the equation for solids flow rate is $Q = V \times W/L$, where Q is the gravimetric solids flow rate, V is the belt velocity, W is the net weight of solids on the weigh-span, and L is the effective length of the weigh-span (horizontal projection on inclined conveyors). To use this equation for the selection of a measuring element: (1) Establish an appropriate maximum value of Q to meet process requirements; (2) from basic conveyor design, obtain the value of V; (3) determine the value of L by calculation, considering idler roller spacing and conveyor inclination; and (4) solve for the maximum value of W.

Of prime importance to the proper design, use and maintenance of conveyor flowmeters is the recognition, by designers and users, of the conveyor features needing special attention to meet the requirements of good measurement. This is analogous to extra care needed in piping installations where orifice meters are involved. For the conveying function alone, normal conveyor design practice considers such factors as material particle size, angle of repose, and conveyor length and inclination to determine belt width, thickness, velocity and troughing, idler spacing, pulley diameter, and the like. Operations require only that the conveyor be in working order without excess wear and tear on moving parts. The *additional* considerations for flow measurement are often overlooked, even though conveyor flowmeter manufacturers emphasize the measures to be taken. Uniform, well-defined standards for conveyor flowmetering are needed, paralleling those already established for fluid orifice metering.

▶ Designing Flowmetering Installations

Major design features to be considered in solids flowmetering installations fall under two general headings: (1) Maintaining precise geometry and distribution of forces in the weighing section, and (2) keeping the belt velocity constant. So that W/L will accurately represent the net unit loading of the weigh-span, W must be the correct resultant of the lever-fulcrum forces and L must be an ex-

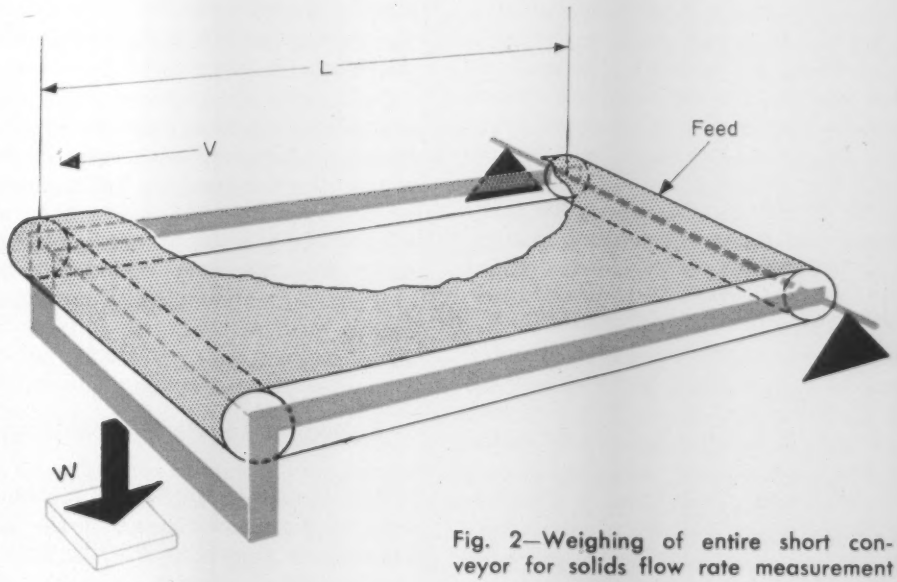


Fig. 2—Weighing of entire short conveyor for solids flow rate measurement

act distance. Hence, all dimensions and alignments about the point of measurement must be closely matched and held. This applies for a distance of two or more idler rollers on each side of the weigh-span, to insure uniform distribution of forces along the line of belt travel.

The centering of forces across the width of the weigh-span also contributes to obtaining the correct resultant load at the point of measurement. Load - shaping devices ahead of the weigh-span, belt-edged guides and proper belt tensioning all serve this end. Since belt tension is at right angles to the measured force or nearly so on inclined conveyors, it has little or no effect on measurement over the tension ranges normally used to obtain good conveyor performance and long belt life.

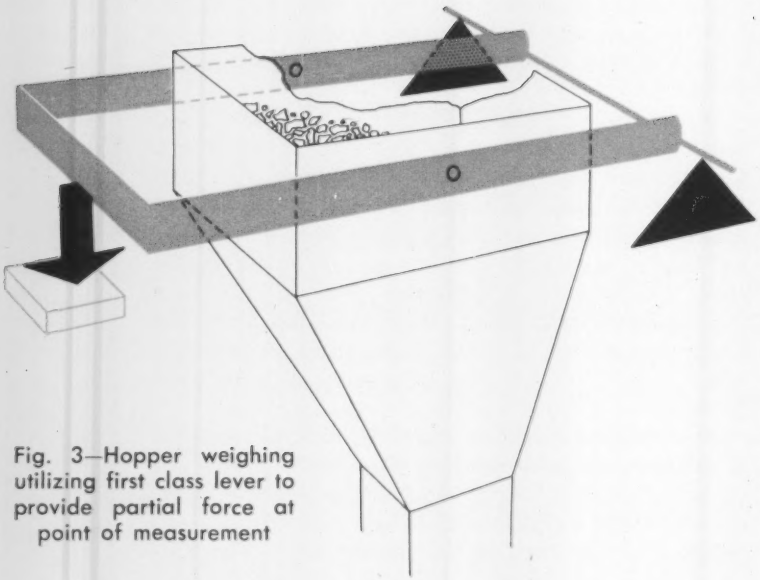


Fig. 3—Hopper weighing utilizing first class lever to provide partial force at point of measurement

Special attention must be given to adequate spillage and dust shielding for the weighing structure. This also applies generally to the return belt, idler rollers (load-carrying), and drive and tail pulleys. Spillage and dust conditions which might be quite tolerable for the conveying function alone are usually a serious source of error trouble and upkeep expense in conveyor flowmetering.

Uniform belt construction is essential to accurate conveyor flowmetering. Variations in weight per unit length and irregular flexure characteristics can be equivalent to considerable percentages of the net solids loading, increasing in effect as the loading becomes lighter. Flexure variance effects are, of course, limited primarily to troughed belts. For this reason, flat belts should be used if possible, where conditions indicate that irregular flexure forces may be significant. Measures for minimizing belt weight and flexure variations also include the use of built-up edges to permit weight adjustment, and prefabricated continuous structure to reduce splice effects.

Since the weigh-span load is the means of measuring solids flow rate, belt velocity variance must not be allowed to introduce error. Either a constant belt speed must be maintained or the weight signal must be compensated for variations in belt velocity, which, of course, complicates measurements. For integrating total flow such dual measurement is common, as integrator mechanisms are well-suited to receiving both signals. In all probability the common usage of conveyor scales as "packed unit" integrators rather than as flow rate meters accounts for some lack of emphasis in present practice on the need for a constant belt velocity.

To maintain an adequately constant belt velocity, several measures are necessary—provide a constant-speed belt drive, keep the drive pulley clean (for constant circumference), and prevent belt slippage. It would seem these direct measures provide the best solution in the long run. With belt velocity compensation, the problem reduces but little, as either drive pulley build-up and belt slippage must be avoided or a direct belt velocity pick-up device must be kept clean, depending on the means by which the compensation signal is provided.

Constant-speed drive may be obtained by using a synchronous motor or an induction motor oversized to minimize speed variation effects over the range of motor loads to be encountered. Of course, more elaborate methods such as automatic speed control can be devised and may sometimes be justified. For flexiblity, the motor speed reduction means should have some degree of ready adjustability, yet maintain a definite speed reduction ratio in operation.

▶ Hopper Levels By Weighing

A common arrangement for obtaining continuous weight measurement of the solids content of hoppers is shown in *Fig.* 3. This consists of attaching the hopper to a yoke which is weighed (net and tare) at one end and pivoted at the other end. Since bulk solids densities vary consider-

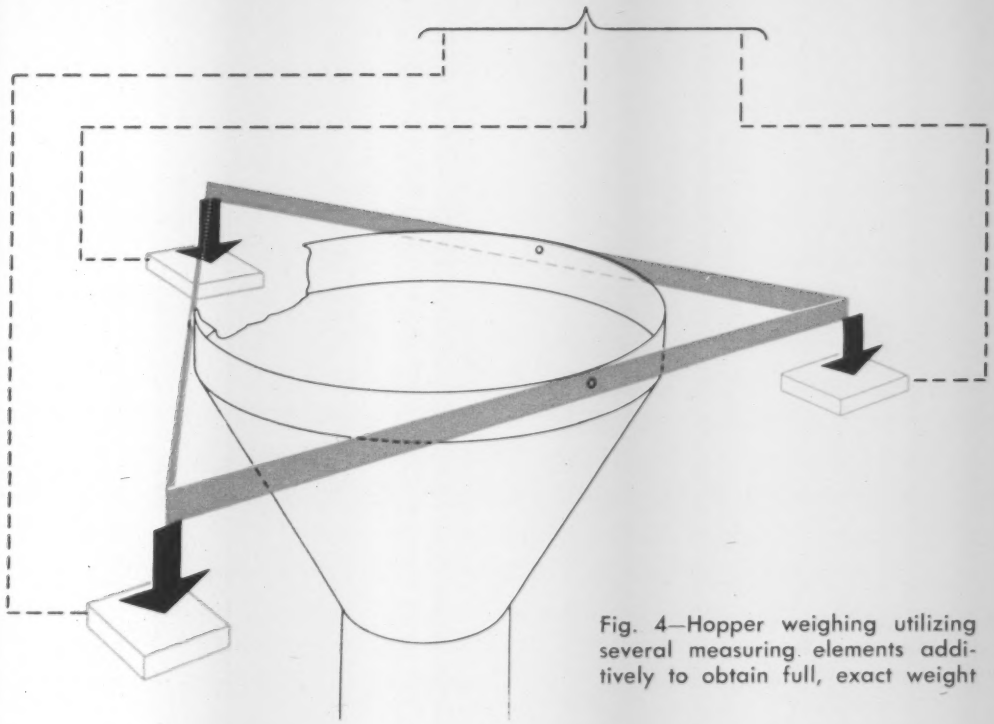


Fig. 4—Hopper weighing utilizing several measuring elements additively to obtain full, exact weight

ably, the physical level range at maximum weight must be accommodated in hopper design by allowing sufficient free-board. The length of the lever used to gain mechanical advantage for the measuring element is varied to meet signal range requirements or overall cost considerations. For stability, the hopper should be constructed symmetrically and attached to the yoke at a point well above the center of gravity of the filled hopper.

This method is quite practical for many applications where a continuous level signal is desired and a highly precise measurement is not necessary. Error is introduced when center of gravity shifts occur through irregular solids surface levels and bulk density variations within the solids mass. Where conditions permit, such errors may be eliminated or made negligible by amplifying the mechanical lever-fulcrum system a bit and suspending the hopper from a single pair of pivots on the yoke. The movement necessitated by center of gravity shifts is then accommodated by a suitably flexible or free-swinging discharge. Although properly designed flexible connections do not affect weighing accuracy, the impact effects of entering solids and the supporting of a portion of the hopper contents by solids choked past the exit connection (not a free discharge) may also contribute to error in weighing.

With finely divided solids, fluidizing techniques may be used to reduce the aforementioned errors. Free drop effects on input may be lessened by conveying entering solids to the hopper rim on a slight incline by belt or by bottom-aerated chute. Fluidizing linings for hopper surfaces contacting the solids reduce localized packing, arching and highly irregular contents surface. Various arch-breaking devices may be employed as well. Thorough coverage of the exit area with porous fluidizing linings greatly aids free discharge, providing better measurement and less chance of flow stoppage by packing or arching.

Where a highly flexible or free-swinging discharge connection is not feasible, an accurate alternative method of weighing hoppers containing solids, *Fig.* 4, is possible. This comprises mechanical scales, or by using multiple weighing elements and adding their output signals as shown. Where this method is used, precautions to eliminate the effects of material input or output and any necessary connections to the solids contained are quite justified. The more positive measurement is offset by the greater complexity, but the method can be required for difficult applications in valuable material weighing and in controlled feeding or proportioning, or where the range of a single weighing element is inadequate.

▶ Conclusions

Difficult handling properties of solids require that the practices of solids process designers give extra consideration to the needs of instrumentation. Such attention will permit attainment of the advantages inherent in highly continuous processes with maximized automatic control. As these advantages have been realized in the petroleum and chemical processing fields, they have drawn much attention and all process industries are trending toward the pattern set by these fields.

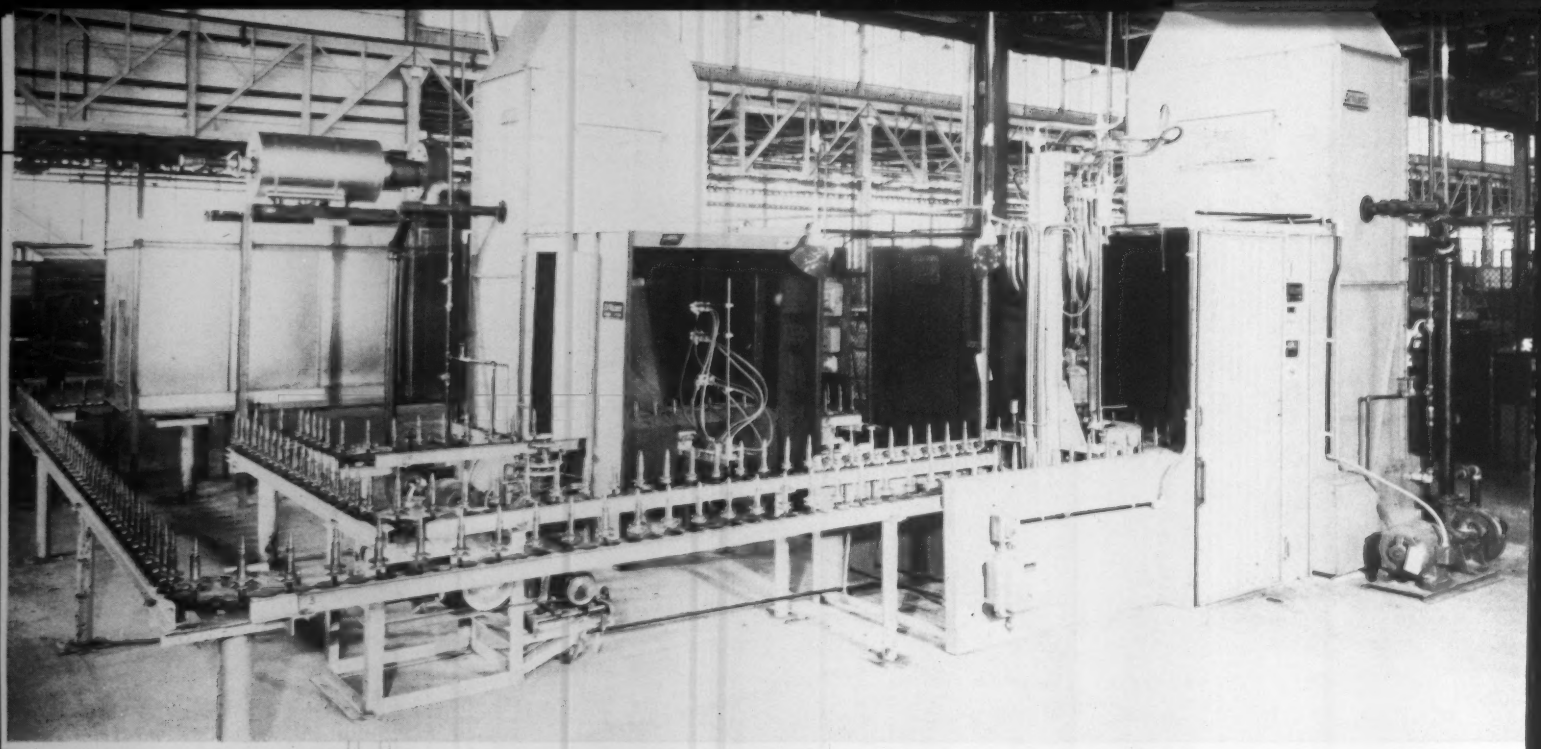


Fig. 1—An automatic chain-on-edge machine showing two spray stations. The station on the right is equipped with a vertical moving spray carriage designed to coat interiors and exteriors of cylindrical objects simultaneously. At both stations the object is rotated rapidly to assure uniform coverage

PNEUMATIC CONTROL FOR PAINT SPRAYING

Since compressed air is always available for paint spraying, control for an automatic system is logically pneumatic

By DONALD J. PEEPS
Vice President, Engineering Director
The DeVilbiss Co., Toledo, Ohio

FINISH, important element in almost every product sale, has been passed back through sales and product engineering to become a processing problem. Coating of shells in wartime accelerated development of automatic means and showed that best results were obtained with automatic spraying equipment instead of the hand operated spray gun. Demand for better quality and faster, cheaper production processes to compete in the postwar market has led to wide acceptance of automation in finish application.

Most popular of the recent spray coating systems developed by the DeVilbiss Co. to improve finish application can be described as a chain-on-edge conveyor equipped with mechanism for automatic spraying, Fig. 1. The conveyor chain is fitted with pins that extend upward and hold revolving spindles which support articles to be sprayed while passing the spraying mechanism.

New developments for the chain-on-edge conveyor automatic system are a device which signals the guns that a workholder is empty or full, and a positive mechanism for moving guns with the work so that a full coat of paint is applied. These two devices eliminate excessive spraying which not only wastes materials but can jam mechanisms of the machine. Clean up time and maintenance are reduced.

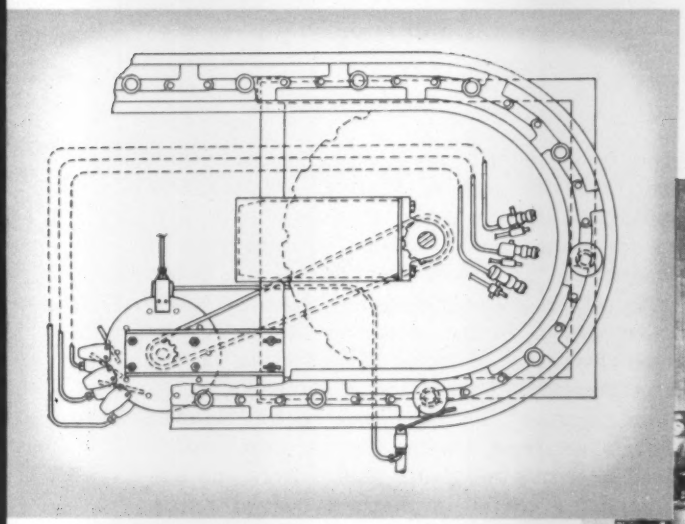


Fig. 2—(Left)—Drawing of the apparatus to successively actuate spray guns as loaded workholders pass by. Time delay between work signal and work passing the guns is provided by "storage of information" in the rotating disks, lower left

Fig. 3—(Right)—Automatic paint spray system with air wash booth and infrared drying equipment. Conveyor speed is 4 feet per minute so that parts are dry when removed from the workholders

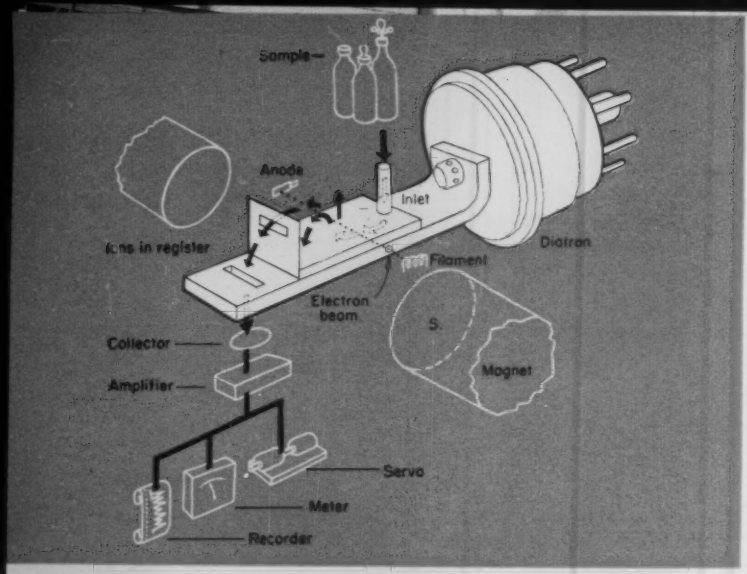
Mechanism which moves spray guns in synchronization with the work being sprayed has means for rapid return to the starting position so that the succeeding article to be coated receives a full coat, eliminating rejects, rework, or retouching at another station. Mechanical cam action returns guns to the starting position in half the spray time, providing smooth movement terminated by an air cylinder shock absorber. By lengthening cam segments and increasing the space between work pieces, the action of following may be prolonged for application of heavier coatings to pieces.

The skip-spray device is a paint saver because the pneumatic pressure sensing element signals whether a holder contains a workpiece or is empty, *Fig.* 2. An extended feeler, actuated by work moving against it, signals the stationary spray guns to either paint a loaded holder or pass an empty. The feeler is located "upstream" from the spray station—the necessary time delay between actuating signal and holder passing the guns is provided by dowels in a set of rotating disks. The actuating feeler signal positions a dowel on each disk indicating a loaded or empty holder. As the disks rotate the dowels approach other actuating mechanisms, each controlling one of the fixed spray guns. Time required for a holder to move from the feeler signal station to a spray gun is synchronized with the time between dowel positioning on the disks and dowel reading by spray gun actuators. Each gun is "fired" in series as a loaded workholder passes. Application at spaced or overlapping intervals is possible by adjusting the actuating mechanism.

Pneumatic pressure, always available at a paint spraying installation, was selected as the control medium. Electric eye devices could have been used but cost would be excessive, not only for the sensing and control unit but for explosion proof wiring. Other devices which signal the paint gun often knock smaller articles from the workholders; by using controlled air as the transmitting agent, the light thrust of the feeler will not dislodge articles.

Automatic spray coating machines are made in a variety of sizes and shapes to meet requirements of individual operations. Systems can be equipped so that articles will be dry when removed from the workholders, *Fig.* 3, governed by speed, length of conveyor chain, as well as material used for the coating operation.

Although maintenance requirements have been simplified so that specialists are not required, regular schedules for checking, lubricating, and cleaning assure optimum finish, and reduction of wear and replacement cost. Finish application is ready to take a place in the continuous line providing faster production and improved product at reduced cost.



INDUSTRIAL PROCESS STREAM ANALYSIS

IN THE PAST, the point of optimum efficiency or product quality was frequently defined in terms of pressures and temperatures at various stages throughout a process stream. Monitoring or control of product quality was based on measurements of these secondary variables. Old sampling methods of questionable accuracy, often requiring several hours. In the interim, costly process deviations remained undetected.

More recently, greater emphasis has been placed on monitoring or control by means of instruments that will analyze the process stream. In refineries and chemical plants, careful regulation of processing conditions is resulting in an increase in standards of quality, reducing the cost of operation, and increasing product yield. This is being achieved principally by sampling or monitoring techniques which immediately show the exact chemical composition resulting from various stages of a process.

For more than a decade mass spectrometers have produced chemical analysis over wide mass ranges in the laboratory. A Consolidated Engineering Corp. industrial model is designed primarily for routine plant monitoring or operation by inexperienced personnel. It will monitor a single component in a gas stream continuously, or several components on a repetitive cycle. A complete analysis of the stream can be readily performed at the operator's discretion. Speed of response is such that accurate measurement of a compound, or actuation of a control device can be obtained within a few seconds.

Every substance has a unique arrangement of the atoms within its molecules. Unique, too, is the manner in which these molocules break up when bombarded by an intense electron beam. These two principles are the basis of operation of the mass spectrometer. Separation of molecular fragments, or "masses", so they can be individually identified is achieved electrically by accelerating them into a strong magnetic field. Here the different particles travel in distinct curved paths. Any desired group of particles can be made to strike a collector target by correct adjustment of the accelerating voltage which alters the trajectory.

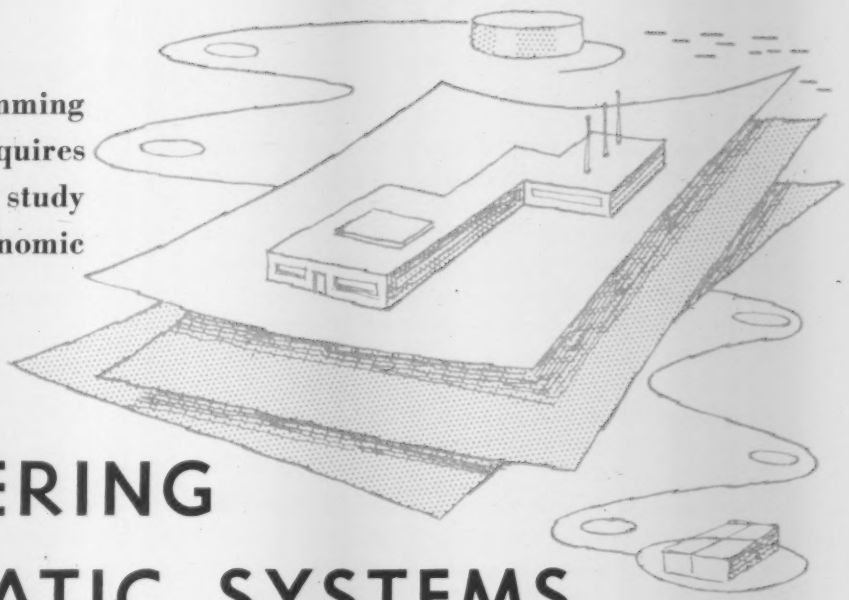
The collector itself is connected to highly stable amplifying equipment which raises the minute electrical signals produced by the impinging fragments to a level suitable for direct indication of fragment abundance on meters and chart recorders or for operation of servomechanisms and other control equipment.

In graphic form, the relative quantities of all fragments formed by a substance constitute its mass spectrum, an unmistakable, positive means of identification. Since the spectra of all pure substances are different, a complex analysis can be performed in minimum time by algebraically subtracting these constituent spectra from the spectrum of an unidentified mixture. In controlling chemical processes, adequate indication is often provided by continuously monitoring just one representative fragment or mass, whose abundance at any one instant is representative of the concentration of the component of interest.

This industrial instrument can determine the percentage composition of a mixture when components of the mixture are present in amounts from trace quantities to 100 per cent. An attenuator on the control panel permits changing the scale of the output meter so that detection of some substances in concentration as low as 10 parts per million is possible. Examples are the monitoring of the acetylene concentration from an acetylene-forming furnace, or the repetitive analysis of the composition of a mixed hydrocarbon stream. Provision can be made where several process streams can be alternately monitored.

Control of such process variables as temperatures, feed rate, and reflux ratio with continuous stream analysis has proven to be economically superior to merely adjusting plant variables to some point of supposed optimum performance. The mass spectrometer can provide continuous stream analysis which permits optimizing of plant conditions. It will readily show pay-out through increased product yield, product quality, and operational efficiency.

Planning and programming automation systems requires careful and complete study to effect desirable economic results



ENGINEERING AUTOMATIC SYSTEMS

By **PHILIP R. MARVIN**
Vice President
Commonwealth Engineering Co.
Dayton, Ohio

PROFITABLE APPLICATIONS of automation call for an understanding of fundamental functions, operations and limitations. Industrial executives should have basic background data at their command to use in putting this relatively new tool to work in places where automation can produce profitable results.

Automation can be economically applied in many dispatching, operating and controlling functions. Automated processes operate without temperament, fatigue or preference as to duties. Automation also eliminates from operations many difficult, monotonous, repetitive and uninteresting details. Automation can't, of course, do everything. Basically its elements are mechanisms that perform routine control and operational tasks.

Effective automation is premised upon executive understanding of automatic systems engineering. A technical analysis of man's job in many operations reveals that he is performing varied specialized and routine tasks. The primary function of automatic systems engineering is to design a system in which these specialized routine tasks will be done by machines. Technology has advanced to the point where this is not only feasible in many processes but represents the most economical way to do the job.

In days past men were trained to keep books. Later automatic bookkeeping machines were developed that took over this laborious bookkeeping, doing the job faster and with greater accuracy. Today in the factory, machines can read gages, calculate necessary adjustments and direct operations to vary rates of flow, pressure, and the like.

Developing the Program

Sound programs are the starting point in automatic systems engineering. Men or machines must be given job instructions. First they are told what tasks are to be performed and how the different tasks are to be done. Then they are told about the problems they will encounter and how to overcome difficulties that may arise. They are also told about special safety and precautionary measures that must be taken. After this has been assimilated they can be told when to start and when to stop. The only difference between instructing a man and a machine is the way it's done.

Instructions are recorded in a great variety of ways; by cards with punched holes, by coded film or tape, by varying voltages or by means of mechanical or electrical adjustments. In considering automatic operations broadly it doesn't make any essential difference how this is done; engineers and technicians can make the decision. The important thing is to make certain that the job data are complete and accurate.

Reasonable assurance can be given businessmen by engineers that any operation or group of operations can be made completely automatic. Unattended operation is technologically and economically feasible for many recognized mechanical, elec-

trical or chemical functions. All that automation engineers need to be told is the program to be executed by automatic operations.

Businessmen haven't found programming easy. The reason lies in the fact that the instructions issued to men haven't always been complete. The performance of either men or machines is seriously impaired by incorrect or incomplete instructions.

Complete and accurate programming data are not easy to develop but whether operations are to be performed by men or machines, complete programming data are equally important in either type of operation. Typical input data are the following:

1. Sequence of operations—model program.
2. Sequence of operations—alternate programs.
3. Specific operational data—time, temperature, voltage, rate of flow, spindle speeds, etc.
4. Control limits.
5. Emergency corrective sequences.
6. Reference data.

Typical handling of program data is illustrated in a vacuum drying sequence. The program calls for opening a valve permitting 25 pounds of a slurry to flow into an empty tank followed by closing of the inlet valve. A control check weigher signals the presence of 26 pounds of slurry in the tank. Reference to stored tolerance data indicates that a 28-pound charge is the upper limit. The 26-pound charge is acceptable but the calculating mechanism is signaled to increase the drying time by a specified number of minutes for each additional pound of slurry. Simultaneously a final water content of the slurry is determined and sent to the calculating mechanism which then refers to its memory component to find the drying time factor for a slurry with this water content. So it goes with the operation relying on basic programming data throughout.

Actual programs are quite complex. They must include full details on sequential and concurrent operations. Speeds, feeds, size, time, temperatures, pressures, rate of flow, voltages and phase relationships are only a few of the factors to be considered.

Programs Must Be Stored

Programs built-in or stored must include not only all of the programming data but data for checking performance. The control information must define the allowable limits both plus and minus for each phase of the operation. Pressures, voltages, and dimensional measurements, for example, must be controlled within established limits.

In addition, sequences must be designed to correct operations when actual performance deviates too far from acceptable performance tolerances.

Man feeds orders into the automated operation by setting controls, by telephone, by radio, by pushing buttons or other means. While the automatic installation is in operation on one program, if orders are received to switch to another, it must put this new program into operation.

Programs to Direct and Control

The following functions must be performed in applying stored data to direct and control operations:

1. Orders must be accepted.
2. A program of sequential and concurrent operations must be selected.
3. Operating data are computed.
4. Operations are started, regulated, timed and stopped.
5. Operations are audited.
6. Continuous control checks are run on operations.
7. Drift and deviations are corrected.
8. Calls for assistance in advance of major mechanical, chemical or electrical failure are made.
9. Adequate safety and precautionary measures are taken.
10. Operations are shut off when preset limits are reached.

By these ten steps programs are applied in directing automatic systems. At the same time the operations are monitored in order that programs may be altered to compensate for conditions arising within the operations. In this manner flexible dynamic direction is applied to the automatic system.

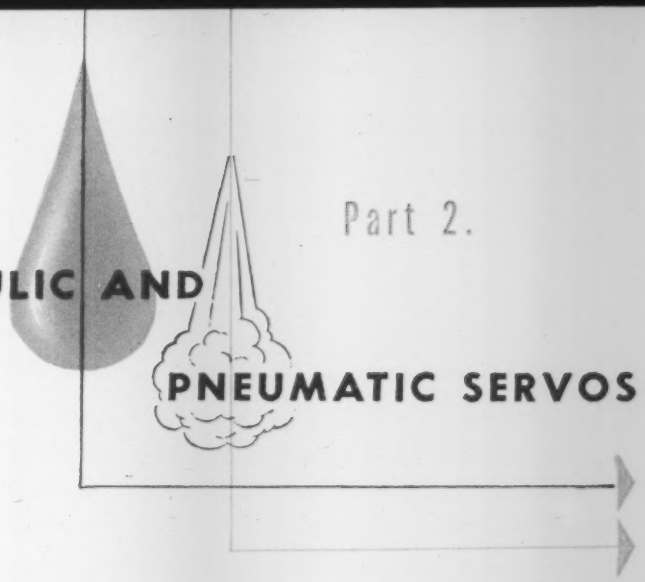
Reliable direction must be guaranteed. Performance at all times is regulated according to preset programs and tolerances. Departures from these plans in the system are controlled by pre-established safeguards. A reliability factor is predetermined on the basis of:

1. No mistakes.
   a. Standby equipment switches in.
   b. Operation is discontinued.
2. Acceptable number of mistakes.
   a. Warning that errors are increasing.
   b. Corrective steps initiated.
   c. Complete shut-off, automatic, when preset limit is reached.

Reliability of automatic operations can be established in advance to conform with requirements of the job to be done. Seldom is this possible when dealing with operations involving a high degree of the human element. More and more, we see machines checking on men. Automatic systems engineering takes full advantage of this money-saving control feature.

The ultimate aim of automatic systems engineering is to develop self-managing systems. Details of the system itself are determined by specific requirements of the job to be done, by an analysis of this job.

Soundly engineered for specific performance, automatic systems represent optimum production design in controlled and economical output for industrial and commercial operations in days ahead.



Part 2.

HYDRAULIC AND PNEUMATIC SERVOS

IMPROVING SERVO PERFORMANCE

Development of various methods of modifying servos to achieve the required performance and response characteristics

By R. HADEKEL
Engineering Superintendent, Hydraulics
Sperry Gyroscope Co., Ltd.
Brentford, England

THEORY GIVEN so far is purely analytical, and can only tell us if a servo with given characteristics will be satisfactory. The next step to investigate the means of improving the performance of servos, which from the mathematical standpoint means modifying their transfer function to achieve whatever characteristics may be required by the functions which the servo must fulfill.

One important method of performance improvement is the use of "passive networks", components not connected to a power source, and having certain specified transfer functions. These networks are inserted in the loop, and their transfer function is then added as an extra factor in the open-loop transfer function of the complete system, thus modifying the latter. Another method, also widely used, is to have "subsidiary loops"; this method is best understood from examples, which will be given presently. A third method, applicable only to servos in which the output is of a mechanical nature—displacement or velocity—is to connect the load to some form of damping device. This last method is not very often used, and is in practice applicable only to low power systems. It will not be described further, but it is worth noting that hydraulic apparatus often has appreciable inherent damping, which may help in improving its performance.

Passive Networks

One frequently used passive network is the "phase advance" type, which is defined as one with a transfer function of the type

$$\frac{K\,(1 + t_1 s)}{1 + t_2 s} \text{ with } t_1 > t_2$$

k being some constant (inevitably) less than unity, called "attenuation" ("attenuation" describes a gain less than unity). This may be regarded as an approximation to the "proportional plus derivative"

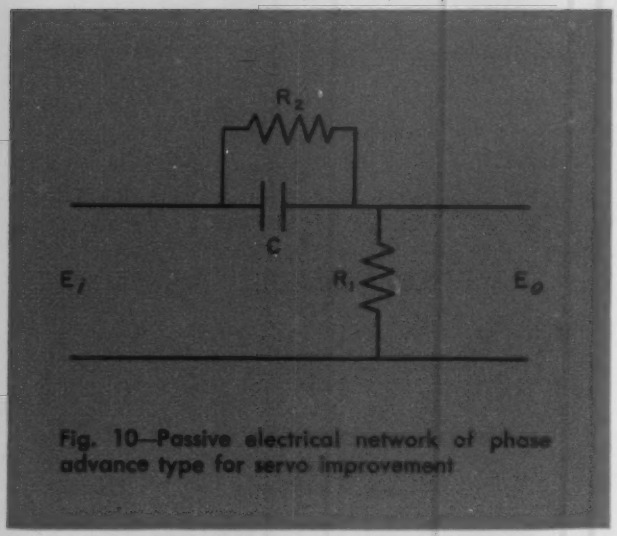


Fig. 10—Passive electrical network of phase advance type for servo improvement

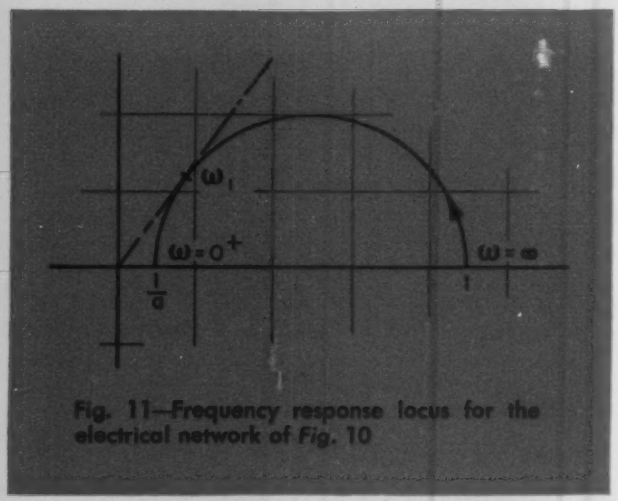


Fig. 11—Frequency response locus for the electrical network of *Fig.* 10

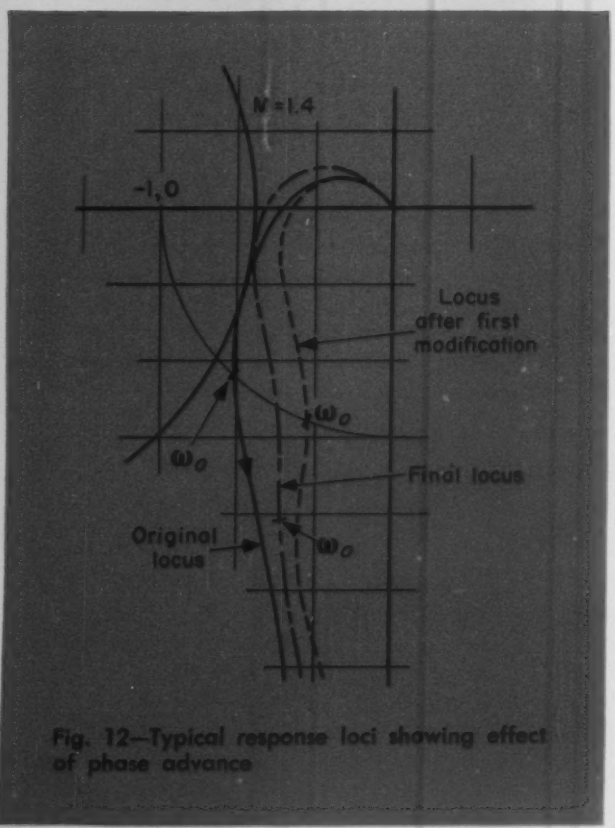


Fig. 12—Typical response loci showing effect of phase advance

characteristic $1 + t_1 s$, which is not physically realizable.

It is instructive to consider an electric phase lead network, shown in *Fig.* 10, and consisting of resistances R_1 and R_2 and a condenser of capacity C. The input and output signals are electrical potentials E_i and E_o, and it is assumed that the output impedance is infinite, the output being practically open-circuited. It is easily shown that the transfer function of this network is

$$\frac{E_o}{E_i} = \frac{a\,(1 + t_1 s)}{1 + a t_1 s}$$

where $t_1 = (R_1 + R_2)C$ and

$$a = \frac{R_1}{R_1 + R_2}$$

The corresponding frequency response is shown in *Fig.* 11. The attenuation is a at zero frequency and unity at infinite frequency; phase angle is zero at zero and infinite frequency, and leading in between. The attenuation a is invariably compensated, or even more than compensated, by increasing the gain factor of some other component in the system.

Fig. 12 shows a typical frequency response locus for a servo which it is desired to improve by adding a phase lead network. It is assumed that the degree of damping is just adequate, the curve being tangent to the $M = 1.4$ circle, as shown. Time constants of the network are chosen so that frequency ω_1 corresponding to maximum phase lead (see *Fig.* 11) is equal to cut-off frequency ω_o of the original servo, as shown in *Fig.* 12. Gain of the remainder of the system is increased so as to compensate exactly the attenuation of the network at the frequency $\omega_1 = \omega_o$. Hence at that frequency the effect of the network is to reduce the phase lag of the servo without affecting its gain, the point ω_o on the servo locus will rotate counterclockwise about the origin; the resulting modified locus is shown dotted in *Fig.* 12. Degree of damping is now higher than necessary, and it is therefore possible to allow a still further increase in the loop gain factor K without exceeding the $M = 1.4$ criterion. This will result in raising the cut-off frequency, scale of the dotted locus being increased in proportion to the further increase in the gain factor. Final increase in overall gain factor may partly or wholly compensate, or even overcompensate, the low frequency attenuation of the network.

Final result is that the cut-off frequency will have been raised, thus improving the high-frequency performance of the servo, and reducing transient errors. The zero frequency gain, or gain factor K, may be slightly reduced, causing an increase in steady-state errors, but in favorable cases K will be unaffected or even increased. If the stability of the uncompensated servo was inadequate, the network would have improved it, probably at some cost to the low-frequency performance.

It will now be appreciated that the mechanism shown in *Fig.* 3 (see Part I—Oct. AUTOMATION) is merely a mechanical phase lead network. In contrast to the electric network of *Fig.* 10, the quantity being "processed", which in this case is mechanical motion, is not attenuated at low frequencies, the gain factor of the network being unity. The laws of nature are not to be so easily cheated, however, and the price to be paid is that the force transmitted is attenuated at high frequencies.

Another important network is the "phase lag" type, which has a transfer function of the type

$$\frac{K(1 + t_1 s)}{1 + t_2 s} \text{ with } t_2 > t_1$$

Ratio of the two time constants in both lead and lag networks is usually somewhere between 10 and 20. An electrical phase lag network is shown in *Fig.* 13. Its transfer function is

$$\frac{E_o}{E_i} = \frac{1 + at_1 s}{1 + t_1 s} \text{ with } t_1 = (R_1 + R_2)\, C \text{ and } a = \frac{R_2}{R_1 + R_2}$$

The response locus is shown in *Fig.* 14. Phase angle is zero at zero and infinite frequency, and lagging in between. Attenuation is unity at zero frequency, and a at infinite frequency.

Fig. 15 shows the Nyquist plot of a servo, performance of which is to be improved by the insertion of a phase lag network. It is assumed again that the degree of damping is just adequate. The network is used in conjunction with an increase of $1/a$ in the gain factor of the system, so that the net effect is to give no change of gain at infinite frequency, and an increase in gain of $1/a$ at zero frequency. The time constants of the network are so chosen that appreciable phase lag and gain increase are restricted to frequencies substantially below the cut-off value. Thus the high-frequency portion of the locus will remain practically unaffected, while at low frequencies there will be some increase in gain, together with increase in angle of lag. The resulting modified locus is shown dotted in *Fig.* 15, and it is seen that the degree of stability (or damping) of the servo is practically unimpaired, increase in lag being harmless if restricted to low frequencies. Net result therefore is that the cut-off frequency is unaffected, and the gain factor has been increased by $1/a$, resulting in a proportional reduction in steady-state errors.

Networks combining the properties of phase lead and phase lag types are quite feasible, and extremely useful in some cases.

▶ Subsidiary Loops

Additional feedback loops may be introduced into a servo system for several reasons. Chief instances are:

1. Servo may be a convenient type of component to use as a member of some more complex servo. For instance, the elementary hydraulic

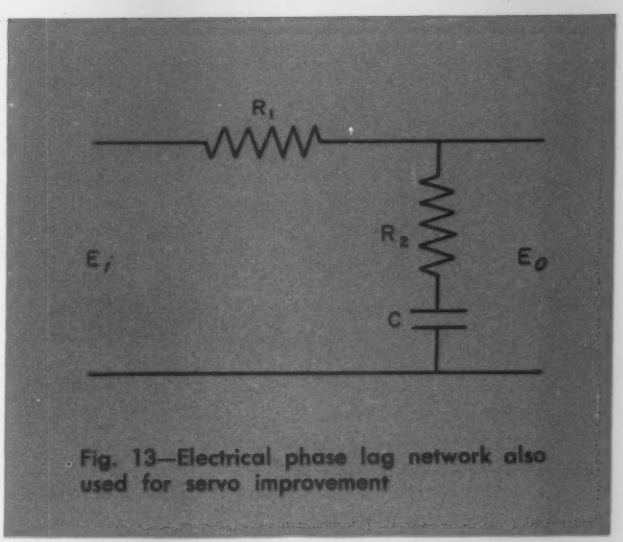


Fig. 13—Electrical phase lag network also used for servo improvement

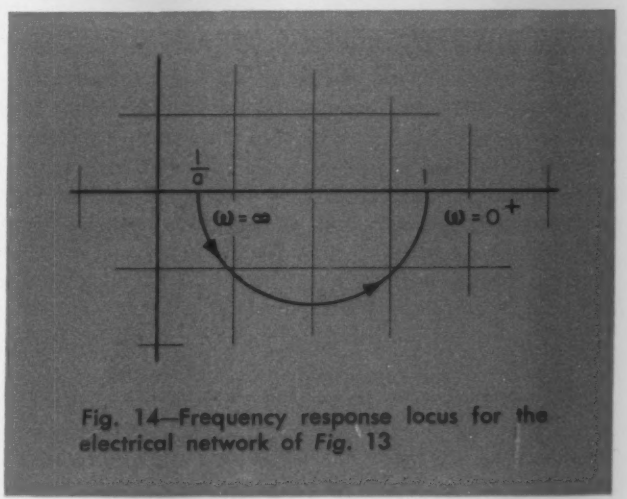


Fig. 14—Frequency response locus for the electrical network of *Fig.* 13

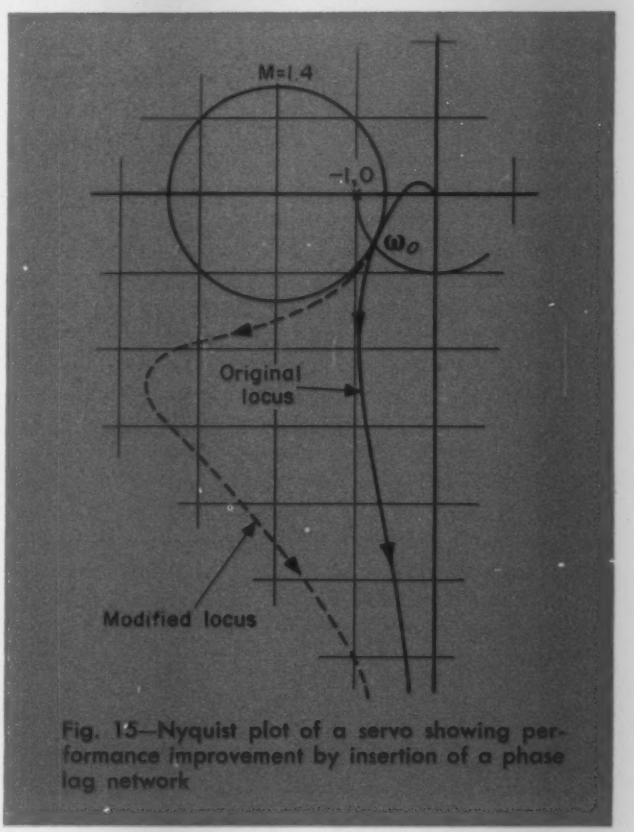


Fig. 15—Nyquist plot of a servo showing performance improvement by insertion of a phase lag network

position servo of *Fig.* 1 (See Part 1—Oct. AUTOMATION) may be regarded as a force amplifier, and is often used as such in more elaborate systems.

2. Feedback (or at least negative feedback, which is the only kind discussed so far) has the property of "linearizing" nonlinear components; thus the characteristic steady-state equation of a servo is $\theta_o = \theta_i$, which is as linear as could be desired, irrespective of the characteristics of the components in the loop.
3. Subsidiary feedback loops are often a convenient means of modifying the transfer function of the system, and may be used instead of passive networks, to which they are often preferable. The present discussion is concerned with this application only.

One very useful device is local feedback through a passive network around an amplifier. *Fig.* 16 shows an amplifier with gain factor k_1, having around it a feedback loop through a network with a transfer function $k_2/(1 + t_1 s)$. If x and y are the input and output of the complete subsidiary loop, we have

$$y = k_1 \left[x - \frac{k_2 y}{1 + t_1 s} \right]$$

$$\frac{y}{x} = \frac{1}{k_2} \frac{(1 + t_1 s)}{\left(1 + \dfrac{t_1 s}{k_1 k_2}\right)} \quad \text{approximately.}$$

If $k_1 k_2$ is made large as compared with unity, this equation becomes the transfer function of a phase lead network, plus if required an additional gain factor $1/k_2$, which may be substantial if k_1 is made very high. Many other transfer functions are obtainable by similar means, while the use of feedback is beneficial to accuracy.

One particularly important form of subsidiary loop is that known as "velocity feedback". A signal proportional to the rate of change of the output (or "output velocity") is obtained, and fed back to be subtracted from the signal at some early stage in the chain, most often at the earliest possible stage, immediately after the differential. The resulting block diagram is shown in *Fig.* 17, the component which generates the velocity signal having the transfer function Gs, where G is a constant. This can only be obtained as an approximation, though a very close one in practice. If $KY(s)$ is the transfer function of the forward portion of the loop, the basic equation becomes $\theta_o = KY(s)(e - Gs\theta_o)$
Which gives

$$\frac{\theta_o}{e} = \frac{KY(s)}{1 + GKs\,Y(s)}$$

The effect of velocity feedback is best studied by considering the inverse loop transfer function e/θ_o, which becomes

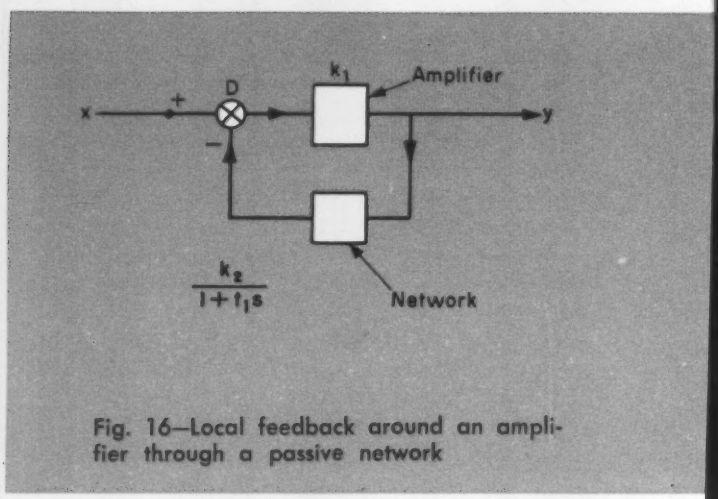


Fig. 16—Local feedback around an amplifier through a passive network

$$\frac{e}{\theta_o} = \frac{1}{KY(s)} + Gs$$

For a harmonic input the inverse open loop response thus changes from $1/KY(j\omega)$ to

$$\frac{1}{KY(j\omega)} + G \cdot j\omega$$

Thus the effect of velocity feedback on the inverse frequency response locus is to add the vector $G.j\omega$. *Fig.* 18 shows a typical inverse open loop response locus. Adding a vector $G.j\omega$ would shift a point such as P to Q, where $PQ = G\omega$. The locus (if it is of the type shown) is thus bent away from the danger point -1, 0, i.e. the degree of damping is increased, or alternatively the gain of the system can be increased, thus raising the cut-off frequency. The effect of velocity feedback is thus similar to that of phase advance. There is one difference, in that velocity feedback inevitably has an unfavorable effect on the steady-state velocity error, whereas phase advance does not suffer from this drawback. However, if this effect can be tolerated velocity feedback is often the more convenient solution.

A somewhat similar device is acceleration feedback, which results in adding a vector $G.(j\omega)^2 = -G\omega^2$ to the inverse locus, thus shifting the point P in *Fig.* 18 to R. Acceleration feedback has no adverse effect on steady-state velocity error.

In electric servos, a velocity signal is usually obtained by means of a tachometer generator. Methods applicable to hydraulic servos will be discussed later.

Servo Apparatus in General

Our discussion of purely theoretical aspects of servo systems is now complete, but before proceeding to the specialized technology of fluid pressure servos it is useful to make a brief review of servo apparatus in general, which may be electric,

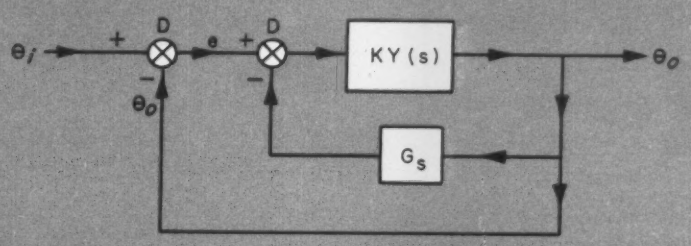


Fig. 17—Block diagram showing one particularly important form of subsidiary loop, "velocity feedback"

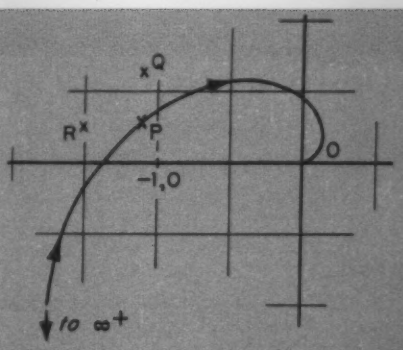


Fig. 18—Inverse Nyquist loop showing effects of velocity feedback (which shifts *P* to *Q*) and acceleration feedback (which shifts *P* to *R*)

mechanical, hydraulic, or pneumatic. Mechanical servos may be built up from elements such as slipping clutches or variable speed gears, but these have only received scant application as yet, and need not be discussed further.

The true character of a servo is determined by its final or high power stages, i.e. amplifier (or sometimes say the last two amplifier stages) and motor. These last stages are governed by considerations often quite different from those which apply to signal transmission gear, passive networks, and other low power devices. In particular, it is often found that electrical apparatus forms the most convenient solution as regards signal transmission, passive networks, and sometimes other components, even when the final stages are hydraulic. Some knowledge of the relevant electrical apparatus is therefore necessary to the designer of hydraulic servos, and a brief treatment of this will be given presently.

In purely electric servos, the motor element is almost invariably an ordinary electric motor (ordinary, that is, in its principle; the detail design may be specialized) of the continuously rotating type, followed by reduction gearing. There is a very wide choice of possible power amplifiers, which may be relays (or even plain switches), variable resistors, ordinary electronic amplifiers, thyratron amplifiers, stationary magnetic amplifiers ("transductors") dependent upon saturation effects, and rotary magnetic amplifiers, i.e. variable generators such as the Ward-Leonard and its derivatives, e.g. the Amplidyne. All of these devices have their limitations, and it is only the last class that is suitable for really high powers.

In comparing electric and hydraulic servos, it should be remembered that the latter are of two basic types, those based on control (or "amplification") by a valve, and those using variable delivery pumps as amplifiers. The latter achieve high efficiency in power conversion—they do not depend upon power dissipation for their action—and are comparable from this standpoint to electric servos using variable generators; the complexity of the power amplifier stages is also comparable in the two cases. Valve-controlled hydraulic servos are more or less comparable to most other electric types, but are suitable both for high and low powers. They are extremely simple, although it should be kept in mind that they require a pump and its driving means, whereas electric power is often available without special provision. In weight and compactness hydraulic amplifiers are far superior to electric types—except relays—but part of this advantage may be sacrificed if the pump is electrically driven.

Hydraulic motors of the cylinder type are incomparably simpler and more compact than electric motors plus reduction gearing. They have their limitations, however, because of the elasticity of the high volume of oil which they contain, and which has an adverse effect on performance in some cases. Therefore it is sometimes necessary to use rotary hydraulic motors, which still require reduction gearing, and are comparable in complexity with electric motors, though much lighter and smaller.

As regards performance, all forms of hydraulic motors are far superior to their electrical counterparts. The reason for this resides in the fact that they have a far higher ratio of torque (or force for cylinders) to inertia. This ratio is a rough measure of the maximum loop gain which may be achieved without incurring instability, and therefore of accuracy obtainable from the servo. Significant quantity of course, is the combined inertia of motor and load, but even with high inertia loads the advantage of hydraulic drive remains very strong.

Reason for lower inertia of hydraulic as opposed to electrical actuating devices is fundamental; as pointed out by J. M. Ford[7d], besides the weight of copper and iron involved in electric motors, they are limited by the fact that the tractive force between a magnet pole and an armature separated by an air gap in which flux density is 10,000 lines per square centimeter is somewhat less than 60 psi whereas the corresponding "stress" in hydraulic

[7d] References are tabulated at end of article.

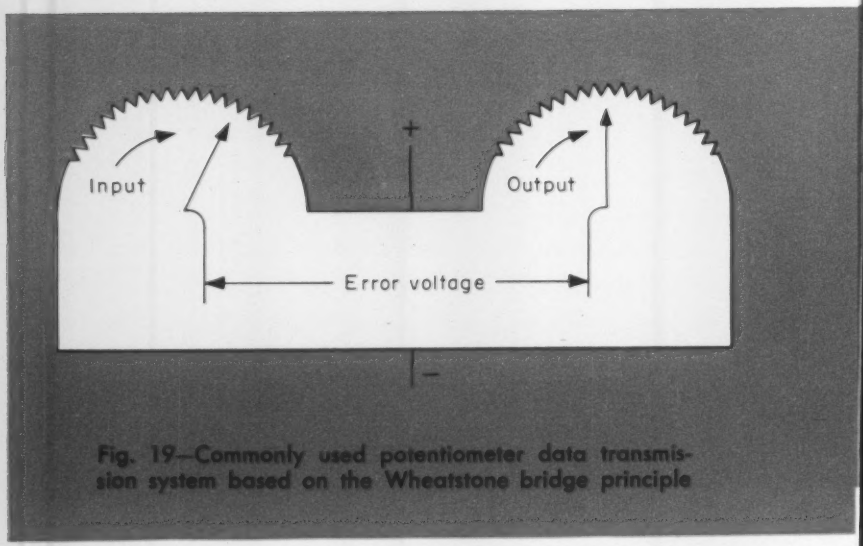


Fig. 19—Commonly used potentiometer data transmission system based on the Wheatstone bridge principle

apparatus is working pressure, which may be several thousand pounds per square inch.

In the case of high power servos requiring rotary magnetic amplifiers, hydraulic apparatus may have a similar though slighter advantage in the power amplification stage. Electrical inductance gives rise to time lags, to factors of type $1 + t_1 s$ or $1 + t_1 s + t_2^2 s^2$ in the *denominator* of the loop transfer function, which have an unfavorable effect on performance if the time constant t_1 or t_2 is high. Time lags are inherent in all apparatus, but those in corresponding hydraulic amplifiers are likely to be smaller.

In the result, hydraulic servos may show up to great advantage where the performance requirements are particularly severe, such as in heavy naval gun control, or in guided weapons. This is well illustrated in the following quotation from S. Y. Lee and J. F. Blackburn's, "Contributions to Hydraulic Control"[10]: "In certain servomechanisms . . . . the acceleration requirements were so severe that no existing electric motors could be used, and the chance of developing satisfactory motors seemed rather remote. Accordingly, the laboratory started a program of research and development of . . . . hydraulic servos."

In aircraft applications, hydraulic servos are usually adopted for the sake of their lightness, while in other cases, such as copying machine tools, simplicity may be the main consideration.

As regards pneumatic servos, the situation is different in many respects. Their performance is rarely of a high order, and they are not suitable for high powers. On the other hand, their simplicity is extreme—which also implies low cost—and this is sufficient to justify their choice for certain applications, of which process control is by far the most important.

Data Transmission Systems

The transmission of electric signals presents no particular problem. For the distances encountered in servos, the transmission of hydraulic pressures or flows is also quite easy, although the elasticity of the oil in the pipes may not always be negligible, and is always detrimental. In pneumatic process control installations, where distances are often appreciable and pressures low, the elasticity of air in the pipes usually has to be taken into account, but apart from this transmission of pneumatic signals offers no serious problem.

In position servomechanisms, where input and output are mechanical displacements, the input and output ends may often be at an appreciable distance apart, and the transmission of mechanical displacements may be quite an awkward problem, especially if the path to be followed includes a number of turns. Ordinary mechanical linkages consisting of cables or push rods, levers, torque shafts, etc., may be awkward and expensive to install, and are subject to inaccuracies due to elasticity, backlash, and friction; sometimes also elastic deflection of mounting points may be appreciable, particularly on aircraft, and may introduce unwanted feedbacks which may have a destabilizing action, although this last effect can always be avoided by careful layout of the linkage. For all these reasons, in many cases it is convenient to resort to some more sophisticated method of data transmission than mechanical linkages. These methods usually perform the function of error measurement as well as transmitting displacement signals. Electrical data transmission apparatus is by far the most effective and convenient, provided the necessary power supply—which in the most efficient methods is high frequency ac—can be made available without too much difficulty.

One commonly used electrical data transmission system is that based on the Wheatstone bridge, shown in *Fig.* 19. The bridge is formed by two potentiometers located respectively at the input and output ends, wiper arms being actuated by input and output signals, which are by assumption mechanical displacements. Potential difference between the wiper arms is then a measure of the error. This potential may then be applied to an electro-mechanical transducer (of which more will be said) which will drive a hydraulic or pneumatic valve. In practice the electric signal obtainable will be very weak, and electronic amplification may be necessary unless only quite low accuracy is called for. This may make this particular system inconvenient for hydraulic or pneumatic servos, although it should not be put out of

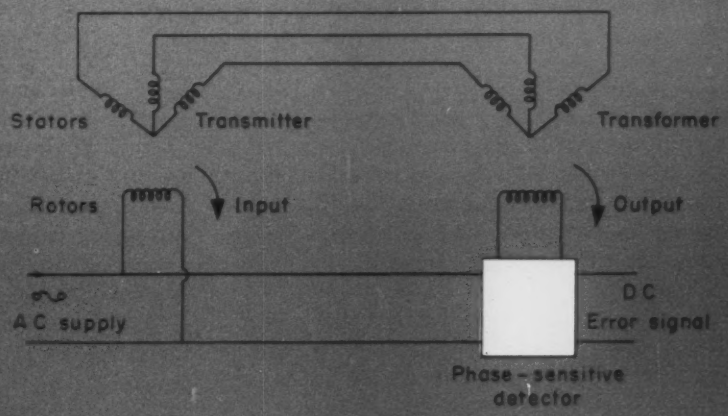


Fig. 20—One of several possible synchro transmitter-transformer systems which provide the most effective means of transmitting electrical data

consideration in all cases.

The hydraulic or pneumatic equivalent of *Fig.* 19 is quite feasible, error signal then being obtained as a pressure difference which is applied to a small spring-centered cylinder, which can drive a valve. Accurate hydraulic or pneumatic potentiometers are, however, rather difficult to devise, while temperature effects on viscosity may introduce additional errors. Hence, such systems are seldom used.

The most effective electrical data transmission systems are those which make use of devices called "synchros", which are not unlike miniature ac motors, and require a single-phase supply at a frequency which may be of the order of 400 cycles per second. One of the several possible synchro systems is shown in *Fig.* 20. Receiver and transmitter units are identical, and have their rotors driven by the output and input signals respectively; these rotors carry single-phase windings, that on the transmitter being connected to the ac supply; the stators carry three-phase windings which are interconnected as shown. The result of this arrangement is that a single-phase ac potential is induced in the receiver rotor winding, which will vary with the misalignment (error) of the two units; the magnitude of the potential is proportional to the error, while its phase angle relative to the supply is zero or 180 degrees depending upon the sign of the error. This potential is fed to an electronic phase-sensitive detector, which produces a dc potential proportional to the error, at least roughly. The dc signal can again be applied to an electromechanical transducer, after amplification if necessary, the transducer being used to drive a valve.

The necessity of using electronic apparatus rules the above system out for many hydraulic servos.

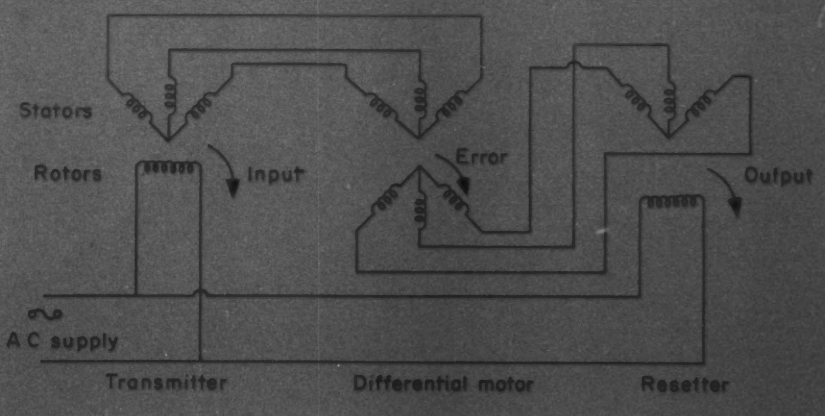


Fig. 21—Diagram of a synchro transmitter-differential motor-resetter system for electrical data transmission

Where electronics can be tolerated however, it has distinct advantages. Initial or error signal is often very weak, and weak signals are rather difficult to deal with in hydraulic or pneumatic apparatus, which requires appreciable driving forces, whereas such signals are quite easy to amplify electronically.

Fig. 21 shows another type of synchro system, which is not open to the objection of requiring electronics. Transmitter and receiver units are the same as those in the previous example, and their rotors are again driven by input and output signals respectively, but both rotor windings are connected to the ac supply. The system further comprises another type of synchro unit, called "differential motor" or "hunter", in which both rotor and stator have three-phase windings, which are connected to the stators of the transmitter and receiver units, as shown. The emf's induced in the transmitter and receiver stators cause a torque to be exerted on the hunter rotor, which will vanish only when the transmitter and receiver units are in alignment, or when the hunter rotor is displaced by an amount roughly equal to the error. The hunter rotor will thus move by an amount equal to the error, and may be directly connected to a sensitive hydraulic valve.

To obtain very high accuracy (2 minutes of arc is feasible) two-stage or "coarse-fine" synchro systems are used, the fine stage being geared up to execute a fairly large number of revolutions over the total input and output travel. The coarse stage performs less than one revolution, and is necessary because in its absence the fine stage units could get out of step by one or more turns. Automatic discriminating devices must be used with this system, detailed description of which is beyond our scope.

Synchro systems have transfer functions different from unity, which must be taken into account in designing the complete servo. Since the units are stock items, these transfer functions must be obtained from the manufacturers, or by experiment—frequency response measurements. More detailed information on data transmission systems can be found in most textbooks and writings[6a] on servos.

Electromechanical Transducers

With the electric data transmission systems of *Figs.* 19 and 20, the error is obtained as an electrical potential. In order to actuate hydraulic or pneumatic apparatus, this must be converted to a mechanical displacement or force, and apparatus which performs this task is called an electromechanical transducer. In some servos, particularly radar tracking gear and guided missile mechanisms, input or error is by the very nature of the device an electrical quantity, and a transducer is unavoidable.

The usual form of transducer is similar to a moving coil loudspeaker movement, or very often an actual loudspeaker movement is used. Under static conditions this type of unit will produce a force proportional to the coil current, and therefore to the applied voltage. In most cases it is desirable to produce a given *movement*, not force, and the coil, or the component which it drives, is then

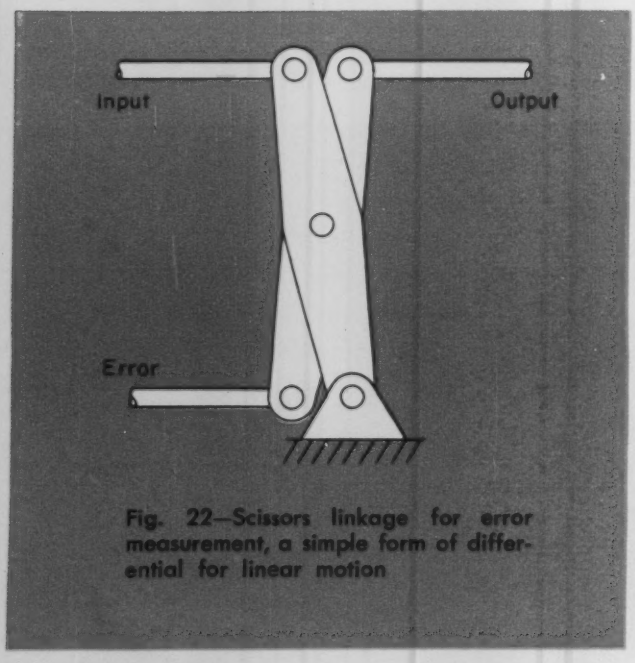


Fig. 22—Scissors linkage for error measurement, a simple form of differential for linear motion

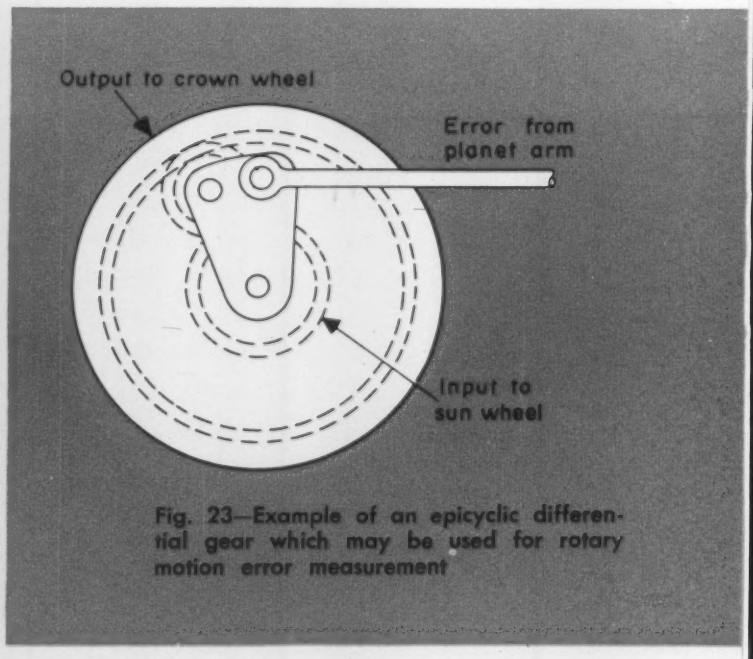


Fig. 23—Example of an epicyclic differential gear which may be used for rotary motion error measurement

fitted with centering springs. To obtain good accuracy the force exerted by the spring must be high in relation to the frictional or other variable forces which the transducer must overcome. In some cases the transducer voltage-force characteristic may be utilized directly; this case will be dealt with in more detail later.

Let E be the applied emf, B the flux density, l the length of the wire in cm, I the current, F the force exerted on the coil, R the resistance of the coil, L the inductance of the coil, m the mass of the coil and any parts attached to it (in grams), g the rate of the centering springs in dynes/cm. Then we have $F = BlI/10$ dynes $= (ms^2 + g)x$, where s stands for d/dt. The current is given by $I = (E - E_b)/(R + Ls)$ where E_b is the back emf, which is given by $E_b = Blsx/10^8$. Combining the above equations gives the transfer function of the transducer as

$$\frac{x}{E} = \frac{Bl}{10\,[mLs^3 + mRs^2 + (gL + 10^{-9}B^2l^2)s + Rg]}$$

The frequency response is obtained by substituting $j\omega$ for s in the usual way. If the transducer is an actual loudspeaker movement, in order to give a satisfactory response the denominator terms in s, s^2 and s^3 must not be too large as compared with the last term Rg, within the audio frequency range. Now the frequencies of interest for most servomechanisms are distinctly below the audio range, and hence for servo purposes all denominator terms but the last may be neglected, and the transfer function is given sufficiently closely by the static characteristic $X/E = Bl/10Rg$.

The above argument applies only if the mass of the component driven by the transducer is not substantially greater than the mass of the loudspeaker cone for which the movement is designed. If this is not the case, the term mRs^2 may not be negligible even at comparatively low frequencies. The term mLs^3 may still be neglected as $Lj\omega$ must be small in comparison with R at audio frequencies. The resulting characteristic would be unsatisfactory as the damping term, i.e. the term in s, would be small, causing a high resonance peak near the natural frequency of the coil. In practice, any valve driven by the coil will most often have a certain amount of viscous damping, which can be deliberately increased if necessary. If the damping force is Dsx, the transfer function then becomes approximately

$$\frac{x}{E} = \frac{Bl}{10\,Rg\left(\frac{ms^2}{g} + \frac{Ds}{g} + 1\right)}$$

Quite recently attempts have also been made to use piezo-electric transducers for driving servo valves. These have the advantage of simplicity and small size.

Mechanical Differentials

In those position servomechanisms in which the data are transmitted by mechanical linkages, some form of differential must be used to subtract the output from the input and obtain the error signal.

A very simple form of differential for linear motions in the floating lever shown in *Fig.* 1. An alternative is the scissors linkage shown in *Fig.* 22. For rotary motion some form of epicyclic differential gear may be used, an example shown in *Fig.* 23.

Very often the most convenient method of subtracting two mechanical motions is that shown in *Fig.* 24, which illustrates a servo strictly equivalent

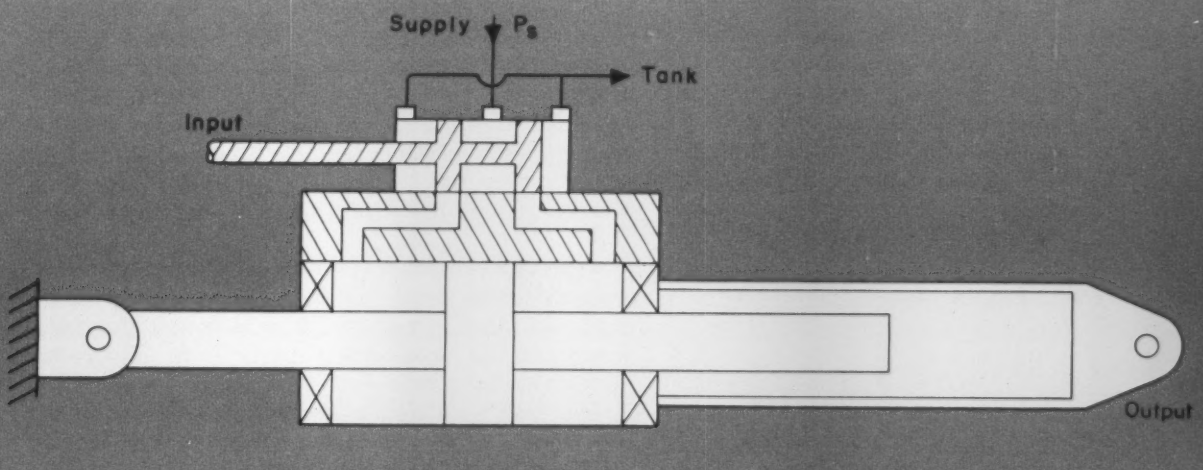


Fig. 24—Feedback obtained by mounting valve on cylinder. Fluid must be supplied to the valve through flexible pipes or sliding joints if travel is small

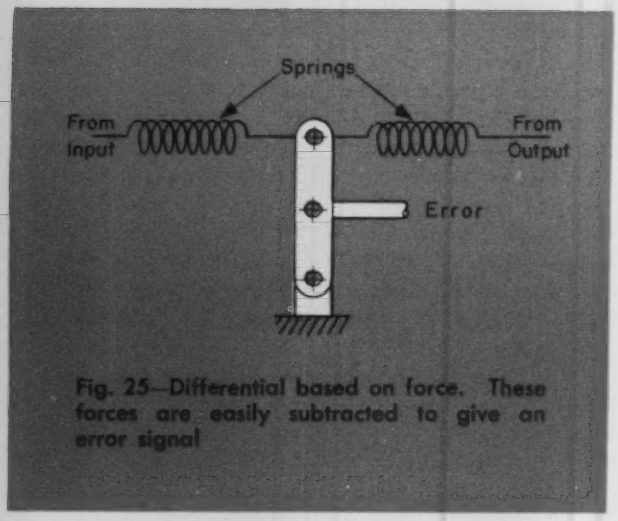


Fig. 25—Differential based on force. These forces are easily subtracted to give an error signal

to that of *Fig.* 1, but with the valve mounted on the cylinder. Fluid must be supplied to the valve through flexible pipes or, if the travel is small, through sliding joints. Equivalent methods suitable for rotary motion are easily devised, in this case fluid must be supplied through rotary joints.

A lever differential of the type of *Fig.* 1 is convenient as a diagrammatic illustration of a subtracting or adding device, but wherever this will be shown in subsequent illustrations it should be read as schematic only, and it should be understood that a construction such as that of *Fig.* 24 could also be used, and would in fact be preferable in many cases.

If the force available at the input end is not too small, a convenient method sometimes is to convert input and output motions to *forces,* by means of springs. These forces are easily subtracted to give an error signal, as shown in *Fig.* 25. This method avoids backlash.

Third part of this series, to cover basic servo elements, will appear in the December issue.

REFERENCES

6. *Proceedings of Convention on Automatic Regulators and Servomechanisms,* Institution of Electrical Engineers, Volume 94 Part IIA, London, 1947: (a) J. Bell—"Data Transmission Systems," (b) J. E. M. Coombes—"Hydraulic Remote Position," (c) G. H. Farrington—"Theoretical Foundations of Process Control," (d) J. W. Broadhurst, T. C. Brodrick, A. W. Foster and G. E. Wheeldon—"Automatic Control in the Chemical Industry."

7. *Proceedings of Conference on Hydraulic Servomechanisms,* Institution of Mechanical Engineers, London, 1953: (a) H. G. Conway and E. G. Collinson—"An Introduction to Hydraulic Servomechanism Theory," (b) N. F. Harpur—"Some Design Considerations of Hydraulic Servos of the Jack Type," (c) T. E. Beacham—"Variable-stroke Pumps for Power Transmission—Some Design Considerations," (d) J. M. Ford—Discussion, (e) P. F. Foreman—Discussion.

8. *Proceedings of Conference on Hydraulic Servomechanisms,* Institution of Mechanical Engineers, London, 1953, P. J. Palmer—"The Forces of the Piston Track of a Variable Capacity Type of Hydraulic Pump."

9. R. Hadekel—"Hydraulic Control Systems," *Machine Design,* April-August, 1953.

10. S. Y. Lee and J. F. Blackburn—"Contributions to Hydraulic Control." 1. "Steady-State Axial Forces on Control-Valve Pistons." 2. "Transient-flow Forces and Valve Instability," ASME *Transactions,* August 1952, New York.

Parts Handling with LIFT Trucks

REDUCTION in both operating time and storage space requirements through mechanized materials handling is possible when electric industrial trucks take over materials handling. General Metal Products Co. uses fork lift trucks for normal shop box handling and movement of dies from die storage to presses, and also has utilized these trucks for small parts handling.

With a hand-truck system, shop boxes could only be stored at floor level. Using a fork lift, the boxes can be stacked four high—quadrupling capacity of the former storage area. This same study revealed that by substituting an electric-powered truck for a two-wheel hand truck, GMP had realized time savings in servicing dies to presses.

Production of fabrications and assemblies constitutes a major portion of GMP's operation. With small parts in particular, volume processing requires efficiency all along the line. The fabrications department produces a wide range of products, from precision typewriter parts and kitchen toaster parts to structural members of tractors.

To speed production in this department, the firm employs a special fork lift truck, designed by the Automatic Transportation Co., equipped with a "roll-over" or revolving clamp attachment. Barrels of small parts are transferred to parts feeding hoppers into position for the next manufacturing operation by truck. Up to twenty such transfers can be accomplished per hour by one truck operator.

Although the primary purpose of this fork truck equipped with revolving clamp is to supply small parts to feeding hoppers, it is also used for such operations as transferring parts from processing containers into shipping containers. Other times it has been used to transfer refuse or scrap to the scrap pit, and in maintenance work in setting motors and other parts onto equipment.

Before acquiring this unit with revolving clamp, press operators fed their own hoppers by stooping to pick up parts from a small container at their feet, an operation obviously not suited for economical automation.

Fourth of a series, AUTOMATION presents another section of the ASME standard "Automatic Control Terminology"; an original work of the Terminology Committee of the Industrial Instruments and Regulators Division. It is hoped these data sheets will assist in furthering the adoption of a standardized language in the field of automatic control

CHARACTERISTICS
OF AUTOMATIC CONTROL

401. The ACTUATING SIGNAL is the difference at any time between the reference input and a signal related to the controlled variable.

402. DEVIATION is the difference between the actual value of the controlled variable and the value of the controlled variable corresponding with the set point.

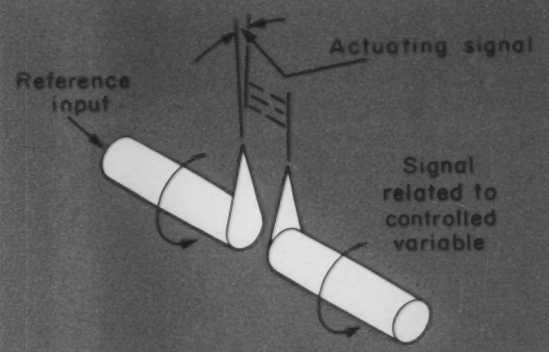
403. OFFSET is the steady-state difference between the control point and the value of the controlled variable corresponding with the set point.

Offset is an inherent characteristic of positioning controller action.

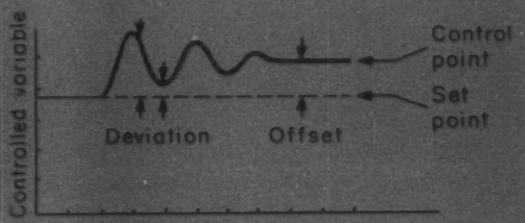
404. CORRECTIVE ACTION is the variation of the manipulated variable produced by the controlling means.

405. CYCLING is a periodic change of the controlled variable (Oscillation is a synonymous term).

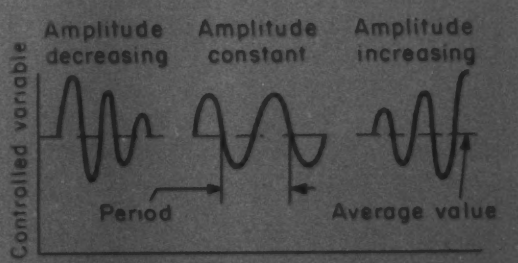
(continued on next page)



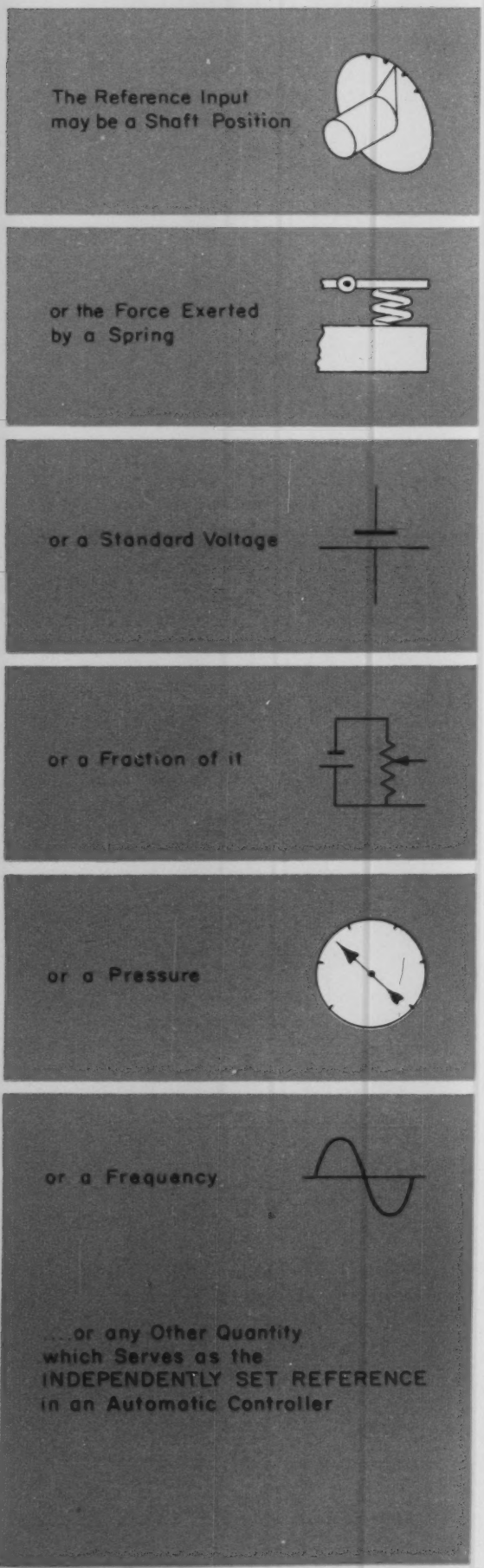
ACTUATING SIGNAL



ILLUSTRATING DEVIATION, OFFSET



THREE FORMS OF CYCLING



406. The REFERENCE INPUT is the reference signal in an automatic controller.

The reference input is the output signal of the reference input elements as determined by their response to the set point input signal. It has the same units as the primary feedback.

407. The SET POINT is the position to which the control-point-setting mechanism is set.

Where the automatic controller possesses a set-point scale, the set point is the scale reading translated into units of the controlled variable. Where a setting scale is not provided, the set point is the position of the control-point-setting mechanism translated into units of the controlled variable.

In some types of automatic controllers, for example, those with the two position differential gap, floating with neutral or proportional-position action, the set point is related to the position of a range of values of the controlled variable. The set point is often selected as the center of this range of values.

The set point may be varied manually or by automatic means, such as in time-schedule or ratio control.

408. The CONTROL POINT is the value of controlled variable which, under any fixed set of conditions, the automatic controller operates to maintain.

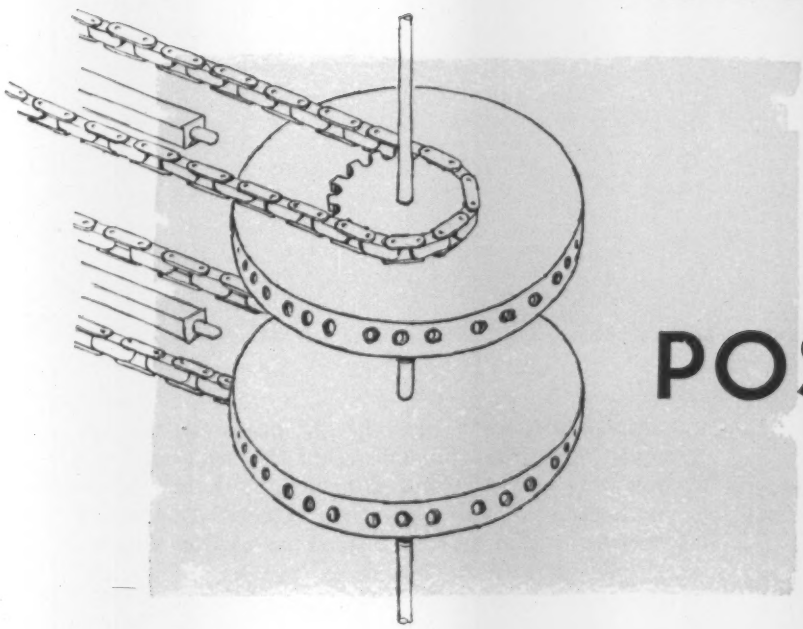
In some types of automatic controllers, for example, those with two-position differential gap or floating with neutral controller action, the control point becomes a control range of values of the controlled variable rather than a single value.

In positioning-type controller action, the control point may lie anywhere within a predetermined range of values of the controlled variable. The control point may then differ from the set point by the amount of offset.

In floating controller action with zero neutral zone, the control point and the set point coincide.

409. PRIMARY FEEDBACK is a signal which is related to the controlled variable and which is compared with the reference input to obtain the actuating signal.

ELECTRONIC SERVO POSITIONING



By **WALTON RAINEY**
Electrical Engineer, Wiedemann Machine Co.
Philadelphia, Pa.

Much has been said but little seen of electronic applications in machine tools. Here is a system that can be applied to many indexing problems

INCREASING POPULARITY of fully automatic operations has created a demand for automatic positioning. For the machine tool builder, positioning is a waste movement that must be done quickly and, as important, accurately. Described here is a servosystem applied specifically to a turret punch press, but basic enough to expect application on other equipment.

The machine to which this servosystem was applied, *Fig.* 1, is a Wiedemann 80-ton turret punch press with compound gaging table. Punches and dies on upper and lower turrets respectively are matched and maintained in alignment by retractable locking pins inserted in bushings around the turret periphery. Turrets, which weigh approximately 2½ tons when fully tooled, are chain connected to a common shaft at the power drive.

Before the servosystem was applied, a manual control system had these features—a manually operated selector switch to retract the turret locking pins, a manually operated run-jog control device to position the turrets, and a manually operated selector switch to return the pins to locking position. The number of manual operations in using the run-jog control was almost indeterminate, and depended upon the skill and interest of the operator. A certain indexing operation requiring 5 seconds by one operator would run as high as 15 seconds with another; daily average was approximately 10 seconds. Obviously, to increase machine productivity, it was necessary to convert as many of these manual operations to automatic control as possible.

The servosystem has an average indexing time of 4 seconds, brought about largely by substitution of a single high-speed manual operation for the several manual operations formerly required. Actually, the time saved in the indexing operation is more important than may appear at first. Now, while the servo is functioning, the operator can concentrate his attention on positioning the work for the next punching operation. It is believed that the application of automatic controls for indexing operation on machines of this type will reduce the floor to floor time by 10 to 20 per cent over other methods using manual control.

Article based on a paper presented at the 18th Annual Westinghouse Machine Tool Electrification Forum in Buffalo, April 1954.

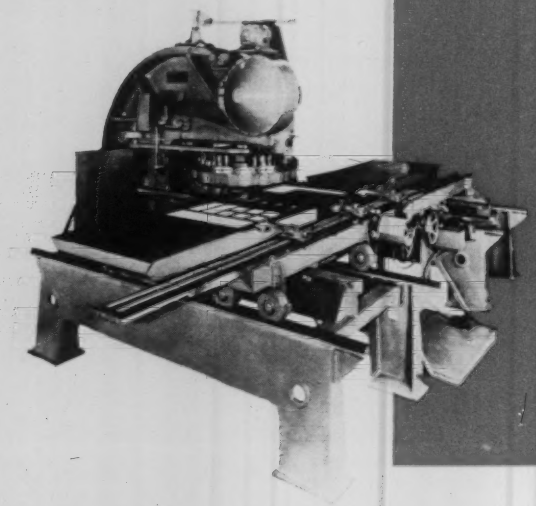


Fig. 1—Wiedemann 80-ton turret punch press showing the 60 x 120-inch compound gaging table and the servo operated turrets

Fig. 2—Exploded view of mechanical components with schematic of the control system. The error signal determines movement to the boundary of the dead-band region

Design Conditions

In addition to automation of existing manual operations, it became apparent in the early design stages that the positioning control required

1. A direction-sensitive device which would limit angular travel to a maximum of 180 degrees.
2. A power drive with reversible, variable-speed characteristics.
3. If possible, some means for obtaining dead-beat characteristics.

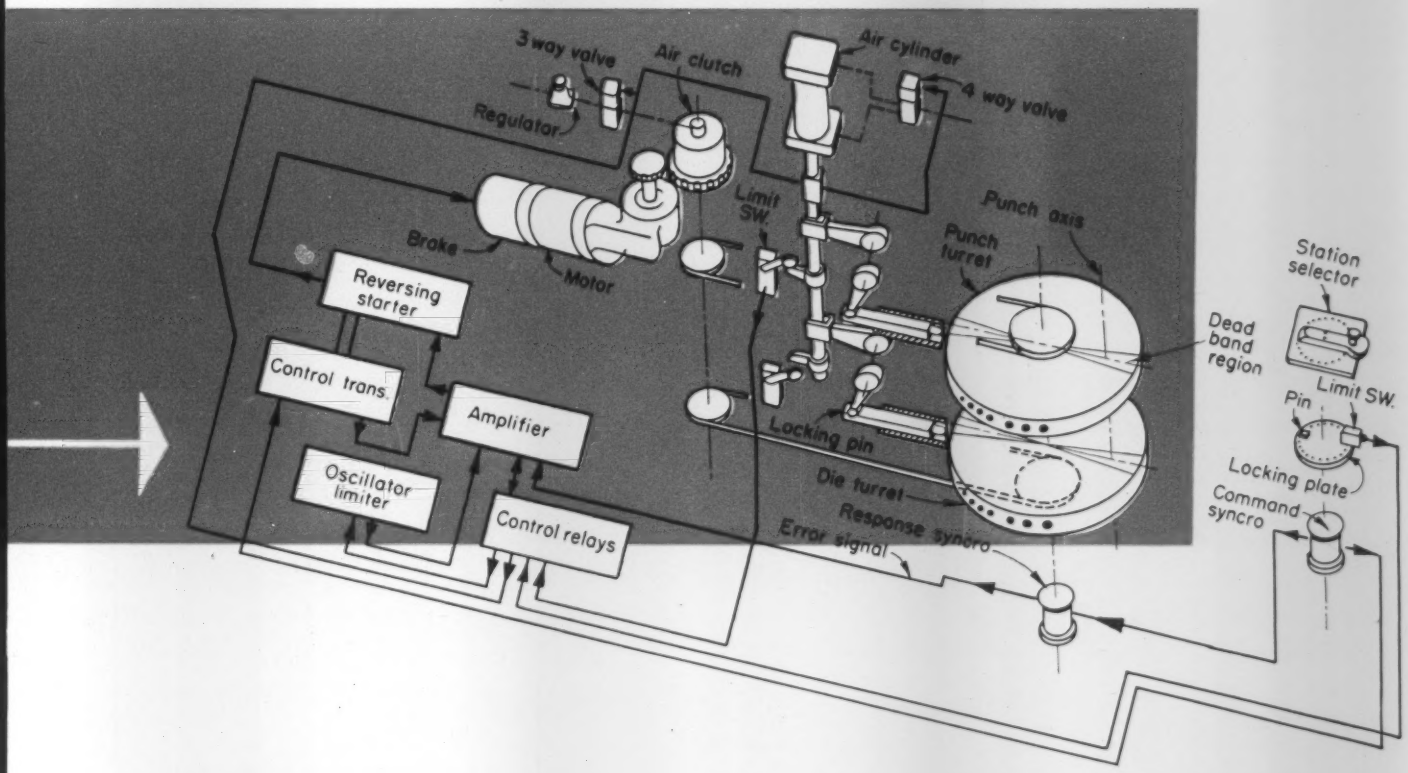
To keep the servomechanism simple as possible, full advantage was taken of pins used to lock the turrets in place. These inherently made available means for precise angular location as well as for dead-beat positioning. The initial endeavor was to achieve a system wherein the turrets would enter an electrical dead-band region so that turret locking pins could be released from a retracted position to contact the turret periphery. In this way, final registry would provide accurate, dead-beat positioning. Use of turret locking pins also provides means for eliminating undesirable effects of random disturbances at the turret, and by suitable auxiliary locking device, similar effects at the command station. With these eliminations, a variable-speed servomotor would not be required; the power drive could be an induction motor suitable for jogging service, and operated by the familiar contactor or "on-off" type control.

Minimum indexing angle for positioning turrets was 7 degrees, meaning that the dead-band region should not exceed 5 to 6 degrees. Since the mass under control has considerable kinetic energy, it was apparent that some form of braking had to be applied to remove this energy before the set point was reached. Switching operation time required for application of the brake, in addition to the actual braking time, would result in some physical penetration of the dead-band region before the turrets came to rest. Design requirements of dead-beat positioning imply that the stopping point should occur close to, but ahead of, the set point. Therefore, boundaries of the dead-band region were not only limited by that minimum indexing angle, but also were directly related to brake efficiency. The system was set up so that turrets stopped about 1 to 2 degrees from the set point, after the braking operation.

Turret Rotation Control

There were some control problems concerning operation outside of the dead-band region. If an attempt was made to make the turrets respond continuously and immediately to the dictates of input quantity, a certain jerkiness of operation would result. Therefore, the desired angular error was first generated and the control locked in that position before the drive motor was permitted to operate. This resulted in smooth, continuous motion of the turrets until they reached the boundary of the dead-band region. At this point and when the initial braking cycle was completed, it was necessary that some means be devised to penetrate the electrical dead-band region and slowly position the turrets through the remaining distance to the set points.

Here is how it was done. The servoamplifier was made to oscillate between the outer boundary of the dead-band region and maximum sensitivity, which corresponded to an error of less than 0.1-degree. A relay oscillator-limiter was used to initiate and maintain this cyclic operation until registry was obtained. The oscillator section causes a relay to make and break on a one-second cycle, charging and discharging a capacitor in the limiter section. During the capacitor charging cycle, limiter contacts momentarily close. The circuit is so arranged that sensitivity is shifted to maximum when the limiter contacts are closed. Therefore, during the charging cycle, the drive motor is given a short burst of power. Essentially then, the oscillator-limiter section is an automatic jogging control, somewhat analogous to a camera shutter.



System Operation

The complete system shown in *Fig.* 2 includes a standard gearhead induction motor with an integral magnetic-disk type brake, geared to an air clutch which has a magnetically piloted, three-way valve for regulating air supply. Clutch output drives the punch and die turrets through a chain and sprocket assembly. An overall reduction of 300 to 1 gives a turret speed of about 6 rpm.

Locking pins are operated through a double-acting air cylinder, which is controlled by a magnetically piloted four-way valve. Ends of the pins are tapered so that by pressing the pins against the periphery of the turrets, they can enter the bushings before exact registry is obtained. Two limit switches indicate the position of the pins to the rest of the system. In the locked position, punch trip-circuits are energized and turret control circuits are de-energized.

Error sensing mechanism for the system consists of a pair of self-synchronous units, or synchros. The command unit is mechanically connected to a station selector, and remotely coupled with the response unit, which in turn is mechanically connected to the lower turret. Provision was made in the mounting of the response synchro to permit a 90-degree maximum rotation, so that the electrical-mechanical system null could be established. This system will generate a signal which is proportional in magnitude and phase to the angular error.

Input Command

The station selector unit, *Fig.* 3, is a special mechanical device designed for high-speed manual selection of the desired station, accomplished by depressing the selector arm button and spinning the selector arm until a scribe line on the plexiglass indicator matches the diamond point at the desired station number on the index plate. Button release initiates the automatic cycle. A simple lever mechanism transmits button motion to a locking plate, disengaging it from a tapered locking pin and permitting rotation.

The locking plate is provided with tapered holes which match the tooling layout, and since the locking plate is directly coupled to the rotor of the command synchro, the latter accurately follows the angular displacement. By this arrangement, input quantity is physically secured in the desired position before any movement of the turrets. A snap-action switch, operated by vertical motion of the locking plate, is used to control relay sequencing at the start of selection operation and to initiate retraction of turret locking pins after selection has been completed.

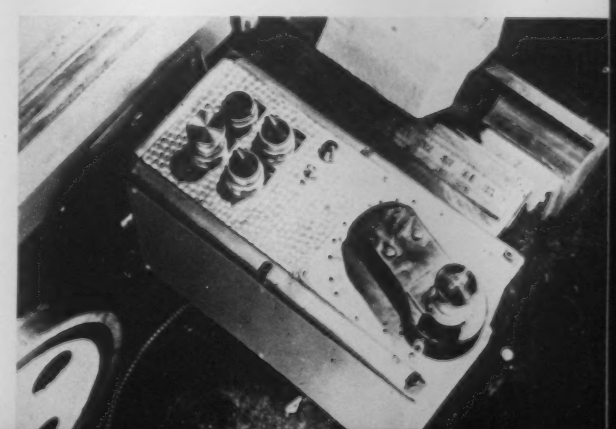


Fig. 3—Station selector unit showing the selector arm with button, and diamond points on the index plate indicating station numbers on the turrets

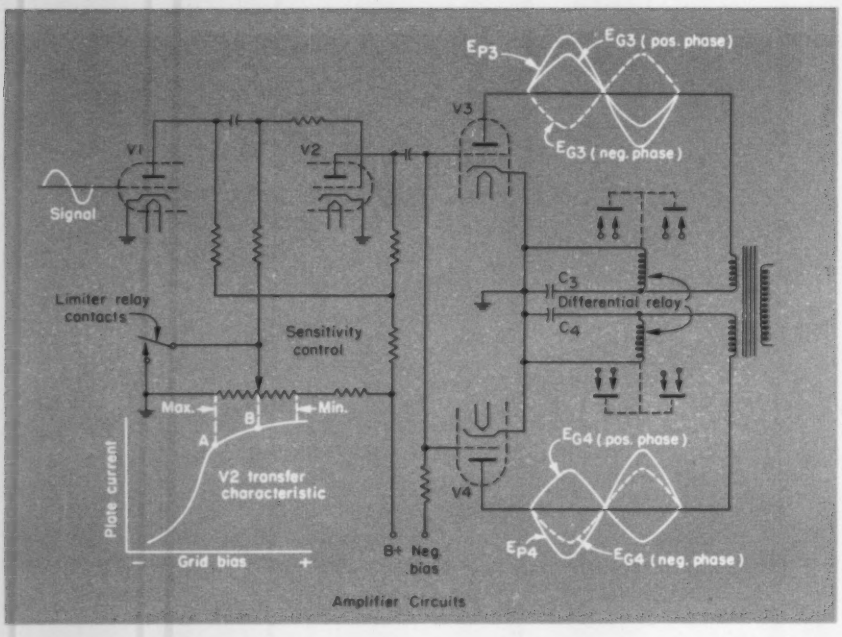


Fig. 4—Amplifier circuits with superimposed operating curves. Plate voltages, E_{P3} and E_{P4} of tubes *V3* and *V4* are 180 degrees out of phase, whereas the grid voltages E_{G3} and E_{G4} are simultaneously applied to both tubes by tube *V2*. Plot of plate current vs. grid bias demonstrates shift of the operating bias point of control tube *V2* from *B* to *A* upon closure of limiter relay contacts

Electronic Circuits

Servoamplifier circuits, shown in *Fig.* 4, perform three essential operations on the error signal voltage—amplification, control, and discrimination. Tube *V1* amplifies the input signal; tube *V2* controls the limits of the dead-band region through a sensitivity control potentiometer. Discrimination or direction control of the signal is performed by tubes *V3* and *V4*, whose plate voltages are sinusoidal and 180 degrees out of phase. The controlled signal from tube *V2* is applied simultaneously to the grids of both tubes so that the average plate current will increase in the tube whose plate and grid voltages are in phase.

On-off control of the power drive in response to the error signal is obtained through a fast-acting, differential relay independently connected in the cathode return circuits of *V3* and *V4*. This relay is a three-position, null seeking type, with positive snap-action characteristics. Capacitors *C3* and *C4* connected across the relay coils, provide energy required to hold in the relay during the nonconducting halves of the in-phase voltage wave.

Returning to control tube *V2*, it will be noted that limiter relay contacts are connected between the contact arm of the sensitivity-control potentiometer and chassis ground. Momentary closure of these contacts will shift the operating bias point of the control tube from *B* to *A*. This is the method employed during relay oscillator operation to penetrate the dead-band region of the amplifier. Subsequent differential relay action will jog the power drive until locking pins and turrets register at the set point.

In regard to the general method of sequencing for a 180-degree error signal the error signal is zero when the selector arm has turned through 180 degrees. While this position represents a false null, there is no possibility of initiating the power cycle from the differential relay, because of the broad dead-band region. However, during selection, a control relay is energized that closes a contact in parallel with the clockwise contact of the differential relay. Therefore, the clockwise power cycle will be initiated as soon as selection has been completed. Once the dead-band boundary is reached, the differential relay will take over, dropping out the control relay, and the cycle is completed.

It should also be noted that control circuits are arranged to permit interruption of the power cycle at any time. This is accomplished either by selector switch operation or by depressing the operating button of the station selector unit. In either case the brake is applied but the locking pins are not released.

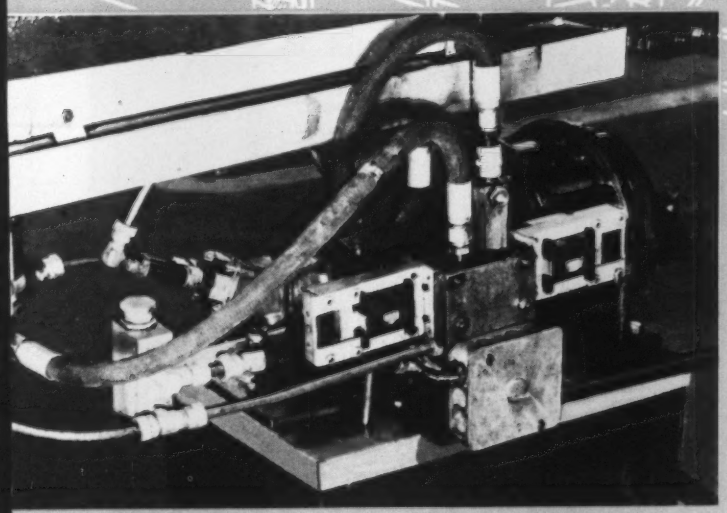
Design Parameters

Careful study must be given to the application of this control system for other types of positioning or indexing problems. If conditions are right, considerable savings in the cost of control and power apparatus may be realized through application of this type control system. Two physical conditions must exist in regard to the object or mass under control. There must be finite points of location which do not change and there must be a suitable locking device available for securing the object at these points of location. When these two conditions are present a simplified servosystem, similar to the type described, may be successfully applied for high speed, accurate, angular or linear positioning of machine tool components.

BROACHING MACHINES MADE BETTER

. . . automatically

with Hydraulic Engineering by ELECTROL



The Electrol hydraulic installation which provides push button control for broaching tools.

GONE are the days when it was necessary for an operator to advance and return a broaching tool *manually* to obtain clearance space for the working piece.

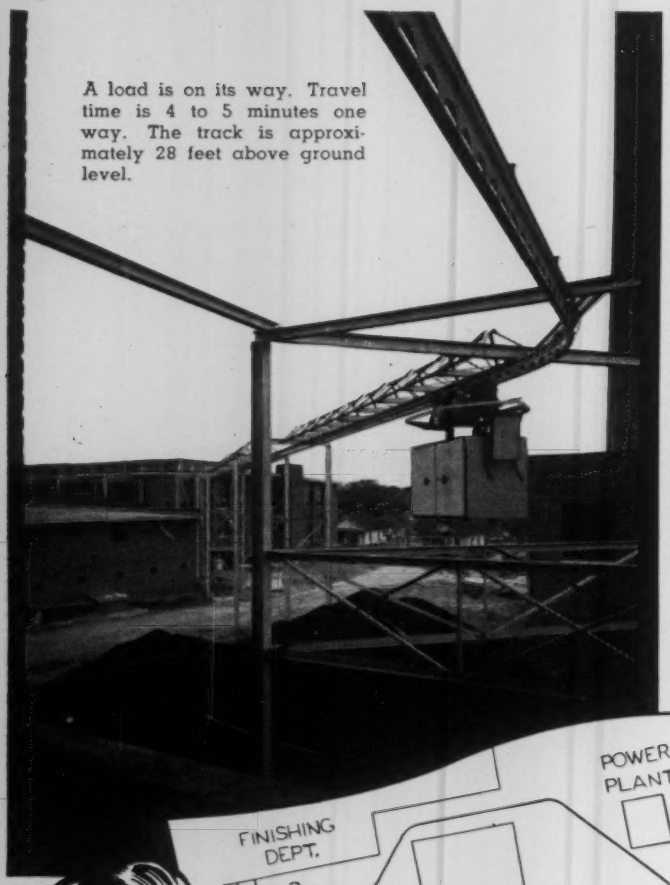
Today, with Hydraulic Engineering by Electrol, this back-breaking task—often requiring the time and labor of two men—is eliminated simply and inexpensively by operating and controlling the broaching tool *hydraulically*.

This way . . . it requires only the pressure of a finger-tip on an electric push button to engage or disengage the broaching tool—or to move the tail stock in either direction from a stationary point. Perhaps, the machines you use—or the products you make—can be made better through the use of hydraulic devices. Electrol's engineering staff will gladly work with you.

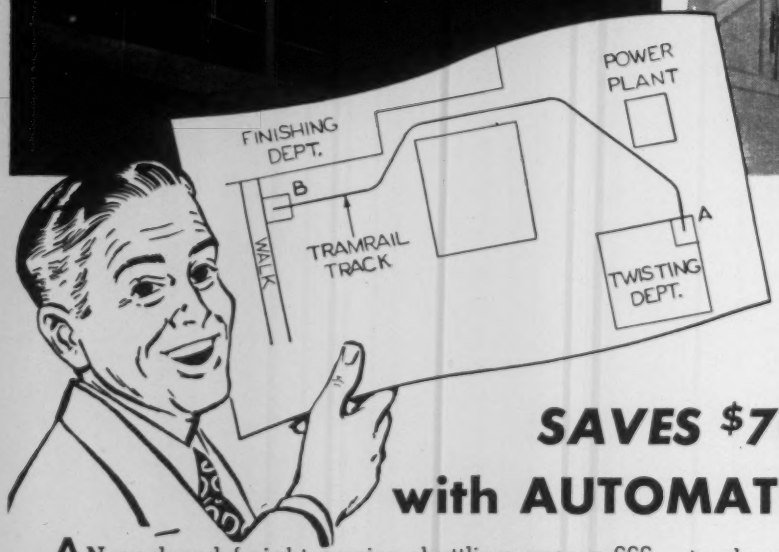
Electrol INCORPORATED
HYDRAULICS
KINGSTON, NEW YORK

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
CHECK VALVES • RELIEF VALVES • HAND PUMPS
POWERPAKS • LANDING GEAR OLEOS • SOLENOID
VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

Better Designed Products Use Electrol Hydraulics



A load is on its way. Travel time is 4 to 5 minutes one way. The track is approximately 28 feet above ground level.



Four trucks are accommodated by the Tramrail freight van, which, at the press of a button, is on its way without attendant. The van stops and lowers automatically at each end of the system. In fair weather or foul it travels with safety and dispatch. Points on each end of Tramrail carrier guard pry open doors of loading station automatically. The system requires very little building space because it need not be enclosed.

SAVES $7000 PER YEAR with AUTOMATIC DISPATCH SYSTEM

AN enclosed freight carrier shuttling over a 666 foot Cleveland Tramrail archbeam track between the Twisting and Finishing Departments of the China Grove Cotton Mills Co., China Grove, N. C., is saving $7000 per year.

This system has eliminated a drudgery that was disliked by labor and costly to management. No longer is it necessary for men to push and lug floor trucks up ramps, on elevators and over long walks between the buildings. No longer is the work held up because of rain or inclement weather. Frequent accidents from manual hauling are done away with.

For the investment involved, this automatic system is paying large dividends in profits and convenience for this mill which is one of the largest producers of thread yarn in the South.

GET THIS BOOK!

BOOKLET No. 2008. Packed with valuable information. Profusely illustrated. Write for free copy

CLEVELAND TRAMRAIL DIVISION
THE CLEVELAND CRANE & ENGINEERING CO.
1373 East 287th Street • Wickliffe, Ohio

CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

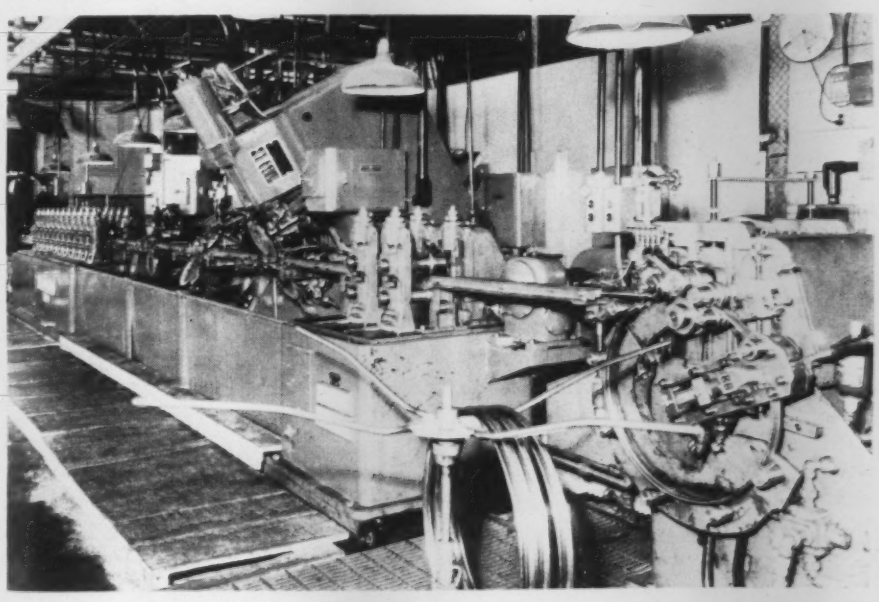
AUTOMATION NEW EQUIPMENT

Machines and plant equipment designed for more automatic operation

AUTOMATIC WELDING

Three seam welders built into a bicycle production line will form, fold and weld flat strip into bicycle rims at rate of 5 to 6 rims per minute. Strip of 0.028-in. thickness is fed through line at rate of 35 fpm. Edges are formed to shape, folded together and resistance seam welded by welders with vertical and special tilted frames. Welders have anti-friction bearing mounted shafts and current collectors to carry continuous current of high welding speed without down time for bearing maintenance. **Taylor-Winfield Corp.**, Warren, Ohio.

Circle No. **1** *on Reply Card*



TEMPERATURE MONITORING SYSTEM

"Signalarm" indicates temperature conditions at various points as scanned by means of red and green signals and an audible alarm. Master unit is set to give warning signals at a high or low point. A green light flashes when scanned temperature is normal, but as soon as temperature passes the pre-set danger point a red light goes on and a bell or buzzer sounds. Operator may silence the audible alarm by pushbutton but red light remains until temperature returns to normal zone. Each "Signalarm" handles up to several hundred thermocouples. Various monitoring systems can be built up from standard units. Additional systems for high speed scanning or for monitoring several independent temperature points simultaneously are available.

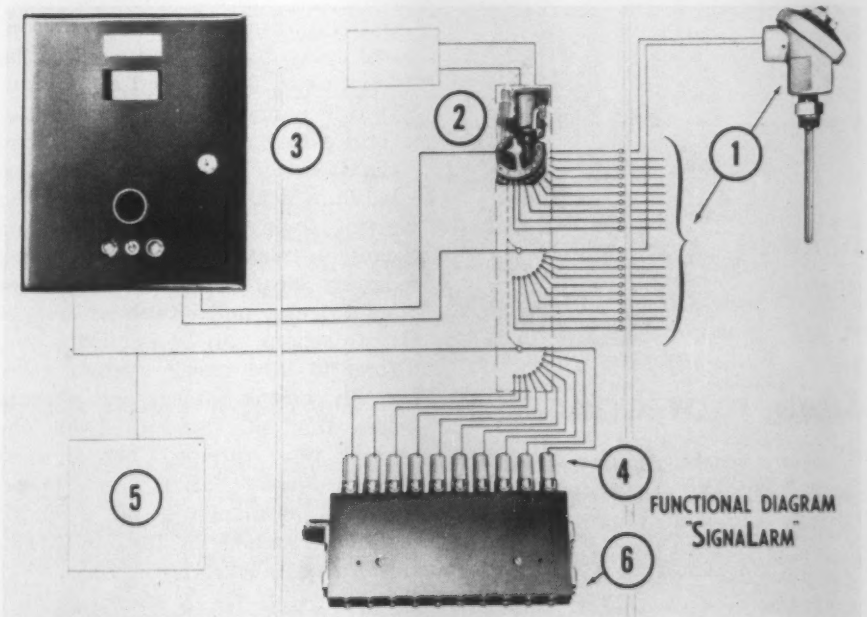
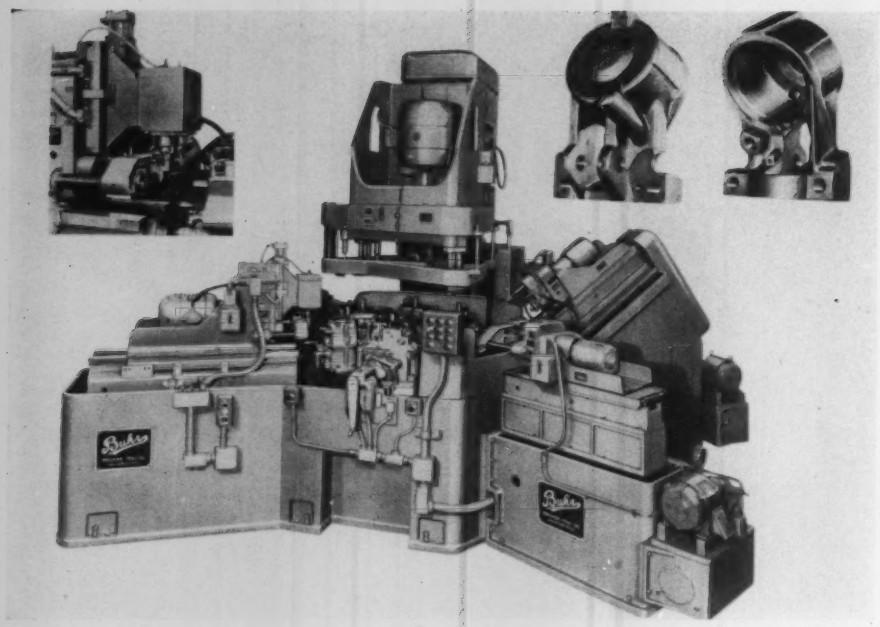


Diagram shows (1) thermocouples, (2) impulse timer and stepping switch, (3) master measuring unit, (4) memory relay, (5) audible alarm, and (6) red and green signal lamps. **Thermo Electric Co., Inc.**, Saddle River Township, Rochelle Park Post Office, N. J.

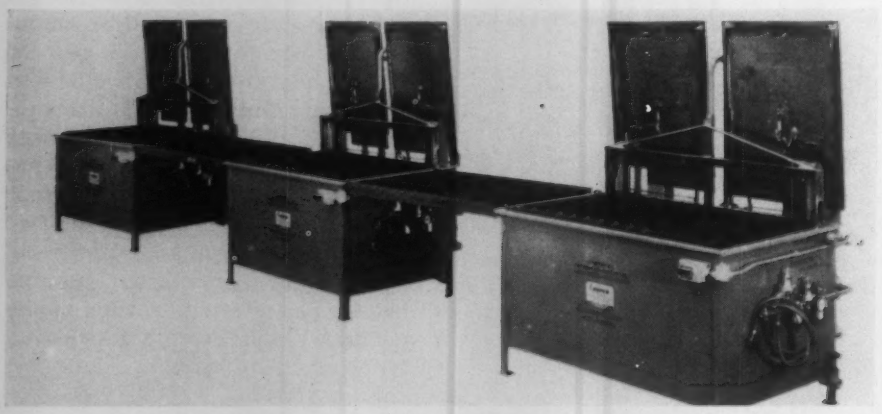
Circle No. **2** *on Reply Card*



PROCESSING TRANSMISSION BODIES

A five-way automatic indexing machine performs 18 operations on transmission servo bodies, has 6-station, 2-place fixture to load workpiece in two positions in each fixture. Production capacity is said to be 124 pieces per hour. Special milling heads are arranged with automatic backup so that cutters do not disturb the close microfinish on their return stroke (see blowup in illustration). Attached tool board cuts tool changing time to a minimum. All parts are interchangeable and held to tolerances, and all components are located by precision bored dowels for precision alignment. Multiple heads are of ball bearing construction with shaved gears and broached and splined drives. Lead screw tapping spindles have precision ground, hard-chrome plated threads. Electrically controlled automatic index is cam and roller type for uniform acceleration and deceleration of indexing movement. **Buhr Machine Tool Co.**, Ann Arbor, Mich.

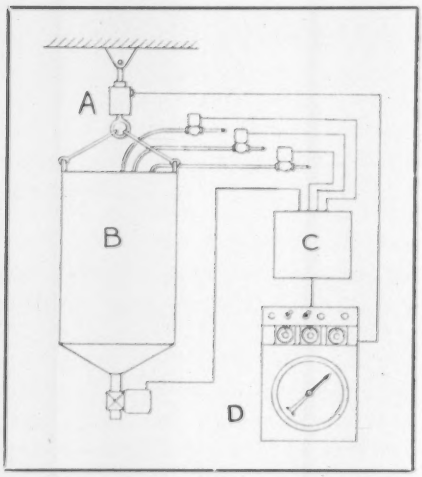
Circle No. 3 on Reply Card



CONVEYORIZED PARTS CLEANING, PROTECTING

A series of five conveyorized machines will clean and rinse with solvent, neutralize fingerprints, and apply rust preventive to bearings, tools, spare parts prior to their packaging, all according to military specifications. A conveyorized dipping rack on the machines and connecting roller conveyor with drip tray between each machine carry parts through metal cleaning processes. First machine agitates parts in solvent cleaning solution, second machine agitates them through a solvent rinse, third unit consists of fingerprint neutralizer, fourth has a second solvent rinse, and fifth applies rust preventive to parts. Last machine merely dips parts whereas the other four machines are agitators. One operator controls entire process by pushing button to initiate and end cycles in each machine. **D. C. Cooper Co.**, 1467 S. Michigan Ave., Chicago 5, Ill.

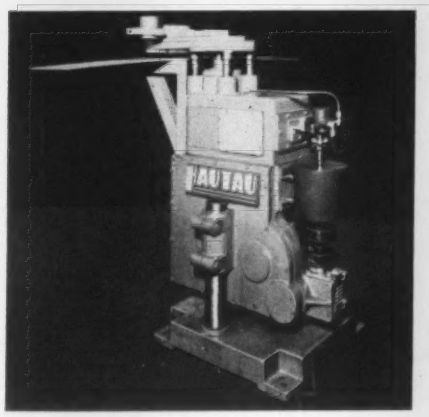
Circle No. 4 on Reply Card



BATCH WEIGHER

Liquids or bulk materials can be handled in batches weighing from a few to thousands of pounds by this automatic weigher. System consists of (A) load cells which support (B) tank or bin and (D) an electronic indicator recording controller which converts load signal into proper functions. Control relay box (C) sequences the functions. Selection dials, graduated in pounds or in percentage of total rating of system, signal load required. Pushbutton initiates batch which can be repetitive or single cycle. Instrumentation and control relay system can be remotely located for convenience or safety, and multi tank or hopper installations can be handled. Automatic tare check system accurately weighs batches and guarantees that all material from one batch has dumped before next batch starts. Each batch is recorded permanently on a chart. **Gilmore Industries Inc.**, 5713 Euclid Ave., Cleveland 3, Ohio.

Circle No. 5 on Reply Card



AUTOMATIC LOADER

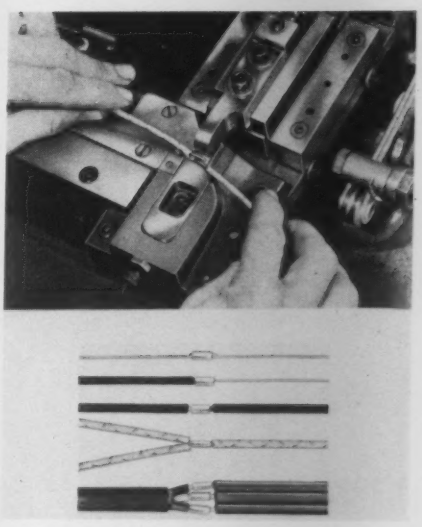
Ideally adapted to loading and unloading parts on stamping presses, forging presses, drop hammers, utility presses and vertical spindle machine tools, this automatic "Oct-O-Pus" loader can pick parts one at a time from a conveyor line, deposit them on press, and unload them onto another conveyor in a total cycle time of two seconds. Two loading arms are rotated through 120 degree motions. Assembly can also be equipped with a single arm to act as a press-to-press loader, automatically handling parts from one machine to another in a line.

"Oct-O-Pus" consists of motor, clutch, brake, speed reducer, gear and cam mechanisms, actuator box which raises and lowers during cycle, and a rotating arm assembly attached to the box which indexes during cycle. Actuator is intermittently powered by motor through an electric clutch and brake unit. Two concentric shafts in the actuator index the arms and control clamping units in each arm. Loader is 46-in. high, requires 22 x 26-in. floor space. Arms are made to suit individual operation and part requirements. **Hautau Engineering Co.**, 721 Wanda, Ferndale 20, Mich.

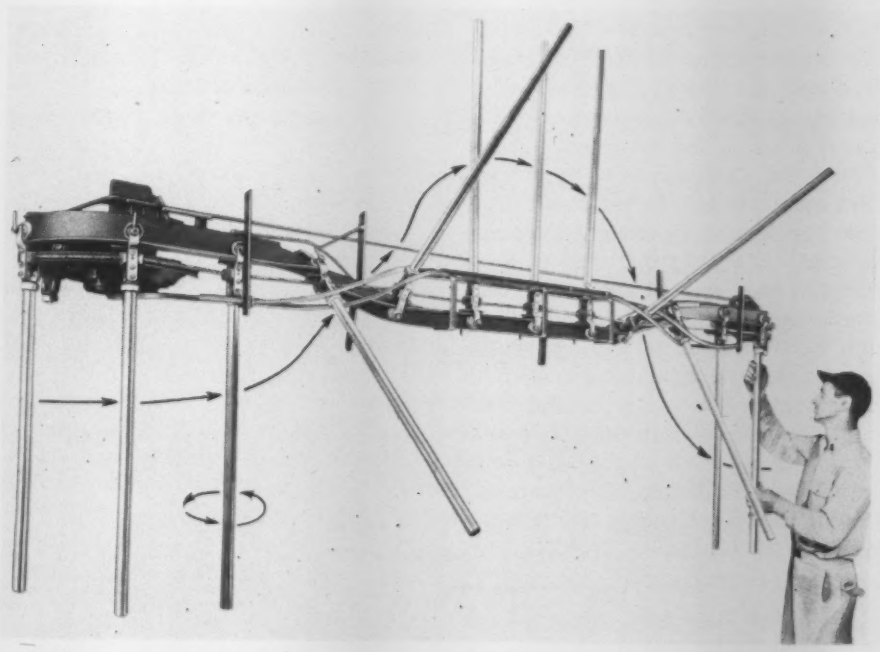
Circle No. **6** *on Reply Card*

WIRE JOINT BANDER

A machine automatically bands together electric wires in a variety of combinations by means of "Autobands". Produced in strip form and supplied on reels, "Autobands" are automatically fed into machine to produce tight, permanent joints in wires. The machine employs no cutting punches and bands wires as quickly as they can be positioned by operator. Continuous wires from either side are located at the full-vision rolling tool and every strand of both wires is joined. Union is strong enough to meet exceptional pull tests and withstand molding pressures. Variety of possible wire combinations includes joints of one, two or three cords, unions of stranded to solid wires, unions of two wires to a single one, etc. "Autobands" can be numbered for identifying motor, generator and telephone leads. "Autoband" method is ideally adapted to wiring systems of air-conditioning units, intercommunication sets, harnesses and electric motors of fractional sizes. **Crimpweld Corp.**, Warwick, R. I.



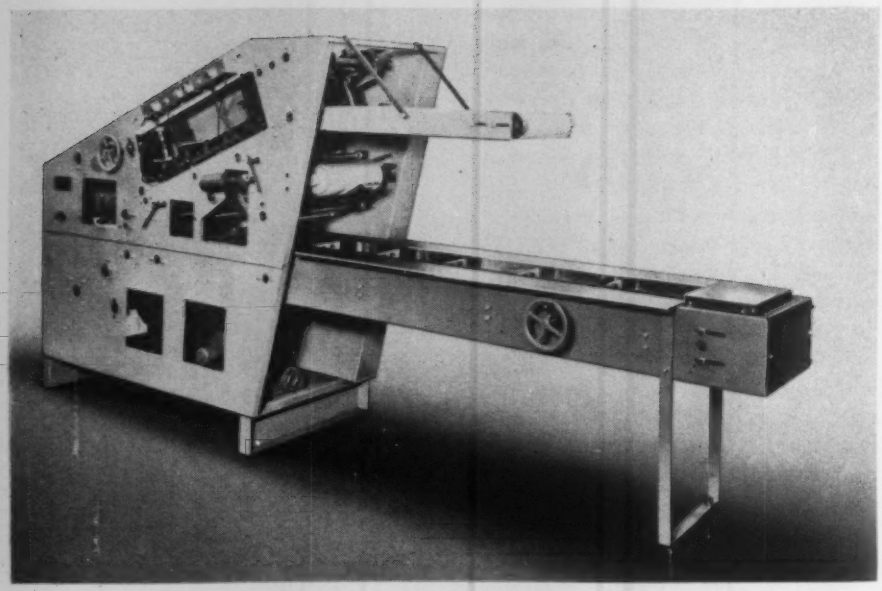
Circle No. **7** *on Reply Card*



EVEN FINISH FOR CONVEYOR DIPPED PRODUCTS

A Dipaid unit, used in conjunction with company's cable conveyor systems, secures a more even finish on parts processed by dipping operations. Unit is located immediately following the dip tank, swings product counterclockwise through a 180° arc, and returns it to normal position by means of two spiral 180° twists in the trolley rail and accessory buffer strips and side guide rails. A horizontally mounted wheel engages a side rail to make the part rotate along its own axis. Twisting motions minimize running, streaking, sagging or beading of finish and help secure an even distribution of coating. Products can be dipped in paint, plastic, liquid latex, lead, zinc, other organic and inorganic finishes. Dipaid can be furnished in lengths and designs for a variety of motions to meet individual specifications. Illustration shows 1-in. diameter tube being transported. **E. W. Buschman Co.**, 4544 Clifton Ave., Cincinnati 32, Ohio.

Circle No. **8** *on Reply Card*

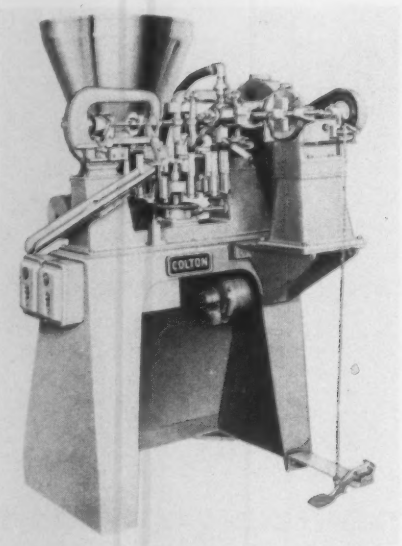


TEXTILE WRAPPING MACHINE AND TAPING UNIT

A line of textile wrapping machines uses transparent, heat-sealing wrapping material for attractive and practical automatic packaging. Model FB can wrap a package 4 x 4 x ¼-in., minimum dimensions, and 12 x 8 x 3-in., maximum dimensions. Goods may be in a tray, on a card, or wrapped around a card. Machine features a long-seam, Teflon coated sealer bar and paper extension gripping and crimping bars to draw wrapping tightly across length of package and to heat-seal a line close to the product. Electric eye will register printed material. One-half hp motor is capable of 1750 rpm, can wrap and seal 20 to 50 packages per minute. Sheets, socks, towels, T-shirts, etc., can be packaged.

A cross-tape unit may be attached to many automatic wrapping machines that will wrap small (3/32 or ¼-in. wide) colored cellophane tape around the package, leaving a pull tab extending approximately ¼-in. beyond the package. Tape is usually placed near the end of the package so that when it is pulled and cuts off end of wrapper the main portion of the wrapper will remain intact and serve as a container for the product. Unit cuts tape to proper length, carries it across the web of the sheet, applies wax or resin to inside of wrapper before it is cut off the roll. Unit is applicable to machines for wrapping chewing gum, candy bars, bandages, cigarettes, crackers, stationery, textiles, frozen foods, etc. **Package Machinery Co.**, East Longmeadow P. O., Springfield, Mass.

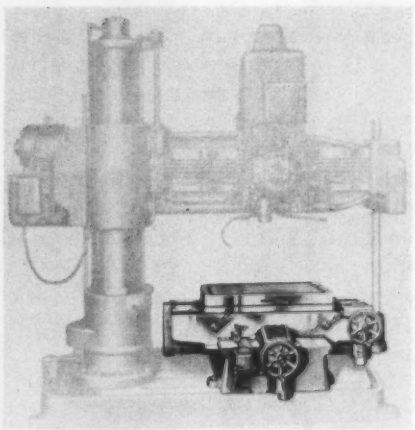
Circle No. **9** *on Reply Card*



TUBE FILLER

Tubes are filled with liquid or paste by accurately metered volume, not by displacement, in this combined filler, closer, and crimper with ejector. Consequent elimination of overfilling "for safety" results in a constant saving of material. For pastes which tend to trap air, a long, bent nozzle is provided to fill tubes from the bottom without entrapping air, a semiautomatic operation (process is fully automatic with liquid and light cream fillers). Positive feed with overload clutch assures feed at proper time in the fill cycle, prevents damage to machine. Pedal operation by a single revolution clutch gives operator positive no-tube-no-fill control as well as control of filling speeds. Double or triple fold closure can be provided automatically. All parts are accessible for cleaning, and all contact parts are of stainless steel. Tubes can be as large as 1½ x 7 in. with a maximum fill of 6 fl oz., and hopper capacity is 15 gal. Speeds range from 20 and 30 tubes per minute for pastes to 40 tubes for liquids. **Arthur Colton Co.**, 3400 E. Lafayette, Detroit 7, Mich.

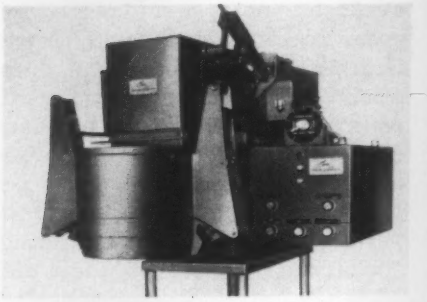
Circle No. **10** *on Reply Card*



AUTOMATIC POSITIONER

Exact reproduction by radial drills of precision drilled, bored, tapped, and reamed parts is accomplished by an automatic positioning table without jigs or stop adjustments. Machine employs two simple duplicating bars which act as permanent record of positions for the job, can be stored and reused later. Positioner has been used and tested for four years on jig borers and automatic positioning machines. Now available as a separate unit, machine is easily installed with existing rigid and radial equipment, and performs accurately within 0.0001-in. Positioner moves work while spindle is stationary and radial remains in clamped position. **Fosdick Machine Tool Co.**, 1638 Blue Rock, Cincinnati 23, Ohio.

Circle No. **11** *on Reply Card*



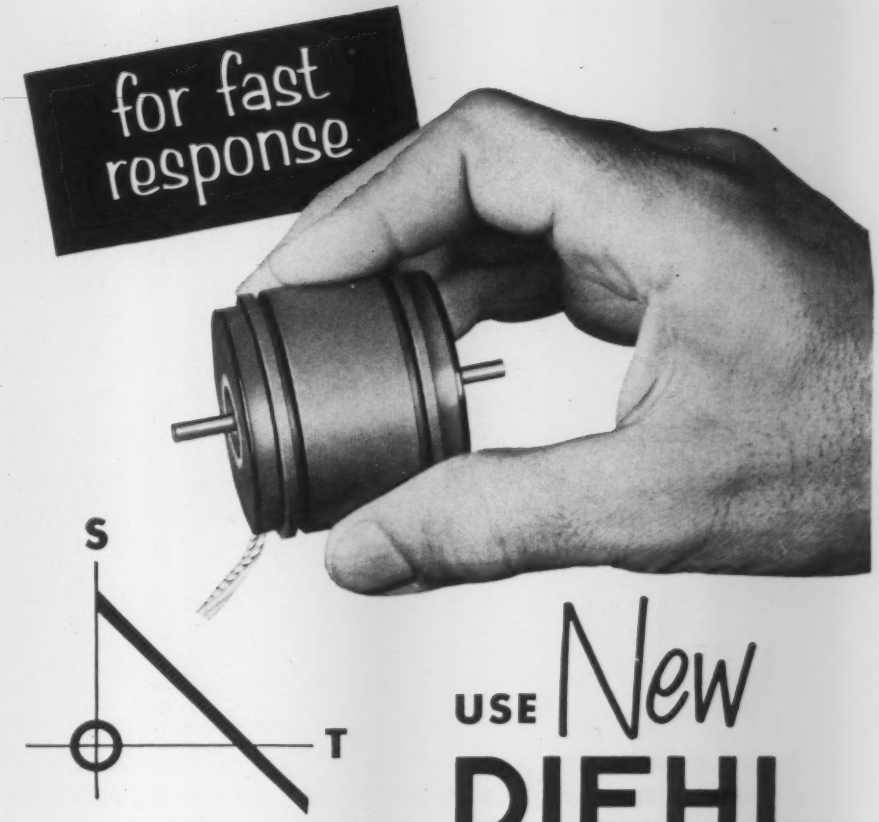
PRODUCTION WEIGHING

Two new scales are designed for gross and net production weighing of granular, flake, pellet or fibrous materials up to 160 lb per cu ft. Models require minimum head room, can be attached directly to storage bin or hopper fed by gravity or conveyor system. Material travels through feeder at right angle to gravity flow so that variation in head pressure has no effect on accuracy of scale. Differences in material density due to changes in batch mix (fertilizers, feeds) are compensated for in seconds. Shockproof leverage system operates without pivots and retains original accuracy indefinitely, assuring freedom from leverage maintenance problems encountered when handling corrosive and abrasive materials.

Gross weighing scale (illustrated) handles up to eight bags per minute, weighing from 25 to 200 lb, within tolerances of one or two oz. Machine holds, fills, checkweighs, releases open mouth bags, drums or cartons. Optional casters and locking screws permit transfer of unit from one station to another.

Net scale preweighs, checkweighs and discharges loads into bags, drums, cartons, valve bag packing machine, or blender or conveyor for batching. Controls can vary loads, frequency of dump and number of dumps per cycle. Unit handles up to 12 bags per minute. A duplex can fill up to 24 bags per minute by employing two standard models discharging into a common bag holder. Checkweight signals on both models signal underweight, overweight or proper weight; machine will not release underweight or overweight load. **Thayer Scale & Engineering Corp.**, 492 East Water St., Rockland, Mass.

Circle No. **12** *on Reply Card*



USE New DIEHL

INSTRUMENT SERVO MOTORS

Designed for use on recording instruments where rapid acceleration and deceleration are of primary importance.

DIEHL Instrument Servo Motors feature a novel construction with an integrally molded stator and housing. Liberal design characteristics are built-in so that long life can be expected even under severe ambient temperature conditions.

While intended primarily for commercial use, these Servo motors meet pertinent JAN specifications for resistance to humidity, salt spray, fungus, shock and vibration.

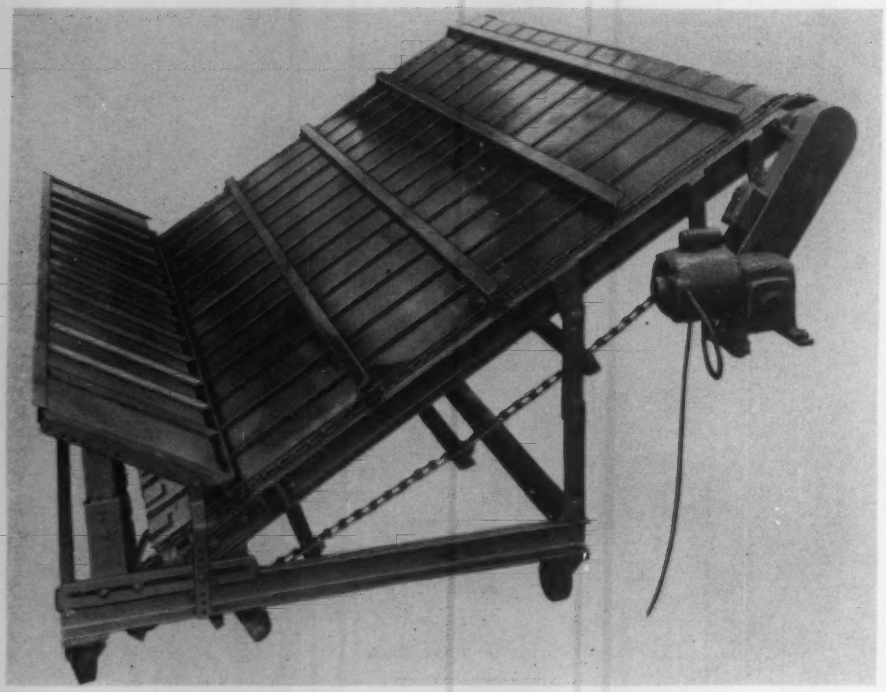
SPECIFICATIONS	DIEHL NUMBER	
	FPE21L-27-1	FPE25L-92-1
Output (Watts)	.1	5
Frequency (Cycles)	60	60
Poles	2	2
Reference Phase (Volts)	115	115
Control Phase (Volts)	50	115
Reference Phase (Watts)	10	17
Control Phase (Watts)	3.5	17
Control Phase Impedance (Ohms)	555	575
Locked Torque (Oz.-In.)	1.5	5.5
Theoretical Acceleration (Rad/sec.^{2})	9650	19000

Our engineering staff will gladly help you select the motors best suited to your specific requirements. A request on your letterhead will bring you a copy of Technical Manual No. A-1154 describing Diehl Servo Motors and related equipment.

Other Available Components:
D.C. SERVO SETS • RESOLVERS
MINIATURE PERMANENT MAGNET D.C. MOTORS

Diehl

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING CO.
Finderne Plant, SOMERVILLE, N. J



STEEL STRIP HANDLING

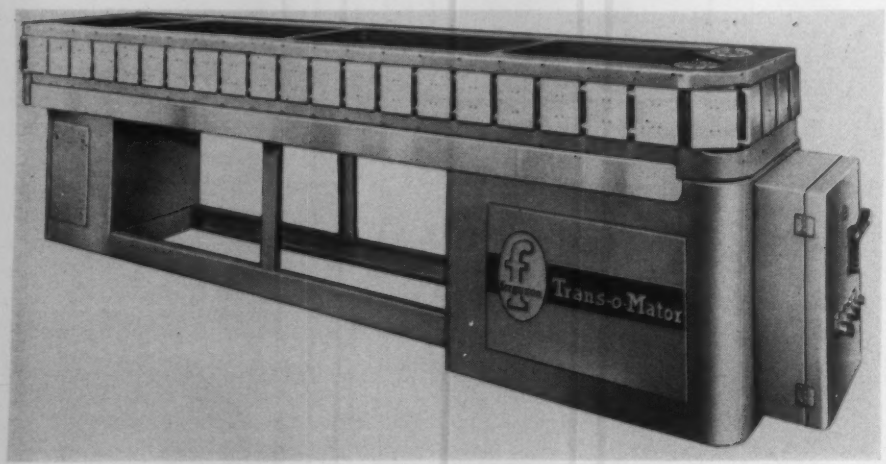
Automatic handler of steel strip off the shearing machine can manage sheet metal of any gage up to 5/16-in. and any width the standard 24-in. back gage allows. Strips are handled as fast as shear cuts them, and only one operator is required to pick off trim cuts and locate material receptacles. Each strip, as sheared, slides down an adjustable pickup chute and is delivered to a table. Strip slips back, is caught by toggles, picked up by horizontal angles connected to endless link chains on either side of the unit. Round steel fingers, welded to angles, reach below table deck, pushing material ahead. Strip is raised to desired point and dropped off into a stacker. Entire unit is mounted on swivel casters, is easily removed for repairs or adjustments. **Fried Steel Equipment Mfg. Corp.**, 528 East 119th St., New York 35, N. Y.

Circle No. **13** *on Reply Card*

TRANSFER MACHINE RETOOLS FOR VARIOUS JOBS

Designed for industries converting to automation, this multiple station transfer machine performs various light machining, forming, pressing, assembling, and inspection operations. It is easily retooled to meet changing production requirements. Two basic models are available. "A" type is designed for such industries as automotive and aircraft where versatility of operations and retooling is important. As many as 6000 pieces per hour can be produced. "B" type operates at speeds up to 20,000 pieces per hour, is designed for paper converting, electrical manufacturing, packaging, and other industries with high production rates and low product costs. Machine, called the "Trans-o-Mator", contains a complete power transmission unit which includes motor, reducer, clutch, roller gear drive for indexing, chain and carriers. There is an electrical interlock system between indexing and tooling power supply. Start, stop, and job controls are provided as well as an automatic scanning device to insure proper function of all stations. **Roller Gear Div., Ferguson Machine & Tool Co.**, Box 191, St. Louis 21, Mo.

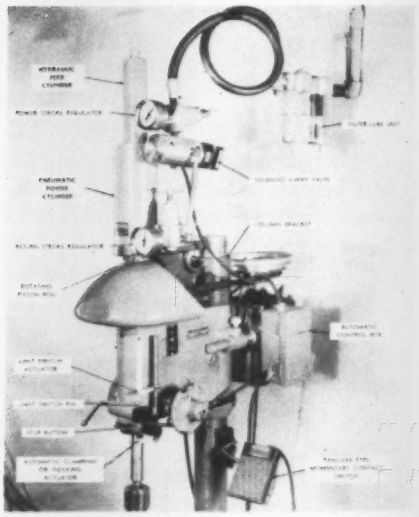
Circle No. **14** *on Reply Card*



TURRET INDEXING

Clutch operated series of turret indexing units features dwell time ranging from 0.835 second to infinity. Models are available with 8, 16, 24, or 32 work stations, and with 20, 30, or 40 in. turret diameters. Maximum indexes per hour range up to 2154. The solenoid operated clutch drive suits indexing mechanism to applications requiring a variable or infinite work cycle, or to those where operator determines indexing cycle by means of pushbutton controls. For drilling cycles and similar operations requiring automatic control, limit switches may be used to prevent indexing before completion of any given operation. Crossover cam and locking device assure accurate positioning. **Swanson Tool & Machine Products, Inc.**, 810 E. 8th St., Erie, Pa.

Circle No. **15** *on Reply Card*



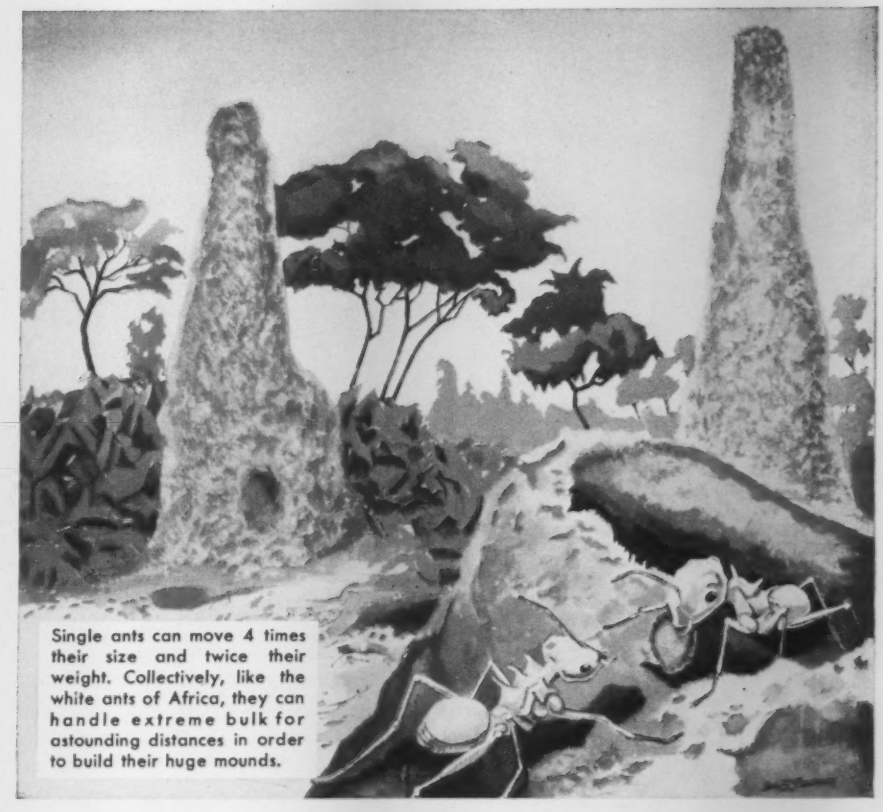
AUTOMATIC POWER FEED

Said to be the world's fastest power feed for drill presses, Rotafeed operates on reduced air consumption for increased production at lower unit cost. Feed is mounted directly in line over the spindle to eliminate the mechanical losses inherent in side mounted feeds and to permit retention of drill press handle for manual operation. Piston rod's threaded end is screwed into spindle which is attached by the other end to a high thrust capacity ball bearing housed in the piston. Larger thrust capacity, due to a larger cylinder bore, permits normal drilling operations in the 40 to 60 psi range and leaves a reserve capacity for multiple spindle operations.

Use of individual pressure regulators and gages at each cylinder port sets up a differential pressure system which eliminates waste of pressure on return stroke. Poppet type flow control valve with controlled flow on return provides hydraulic control for feed. Seat is metal to metal for positive sealing action, and adjustable orifice in stem meters out fluid control to make infinitely variable hydraulic feed possible.

Repetitive accuracy in drilling depth is less than 0.005-in., and with a time delay unit can be held to less than 0.0005-in. Two variations of Rotafeed are available to drill up to ¾ or 1¼-in. depths. **Pneuma-Draulic Co.**, P. O. Box 666, Detroit 6, Mich.

Circle No. **16** *on Reply Card*



Single ants can move 4 times their size and twice their weight. Collectively, like the white ants of Africa, they can handle extreme bulk for astounding distances in order to build their huge mounds.

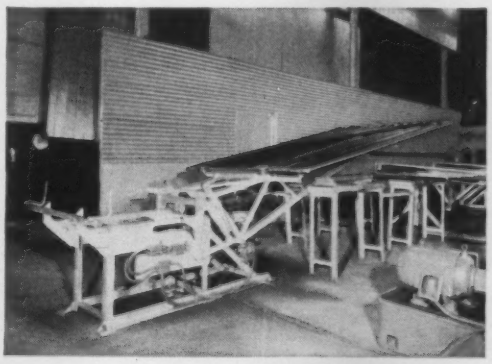
EXPERTS IN AUTOMATION

It was not too long ago, as time is measured, that man was restricted in what he could move from one place to another by the limits of his individual brawn. But now, through science, he need simply to push a button to handle the most cumbersome object.

Automation, the science of automatic material handling, transferring and precision flow control, is the specialty of *Allied*. They have designed and fabricated some of the most unique machines used by industry today.

If you have a problem in material handling peculiar to your business, consult *Allied*. Their staff of automation experts will make a study of your situation and provide a practical and cost saving solution for it.

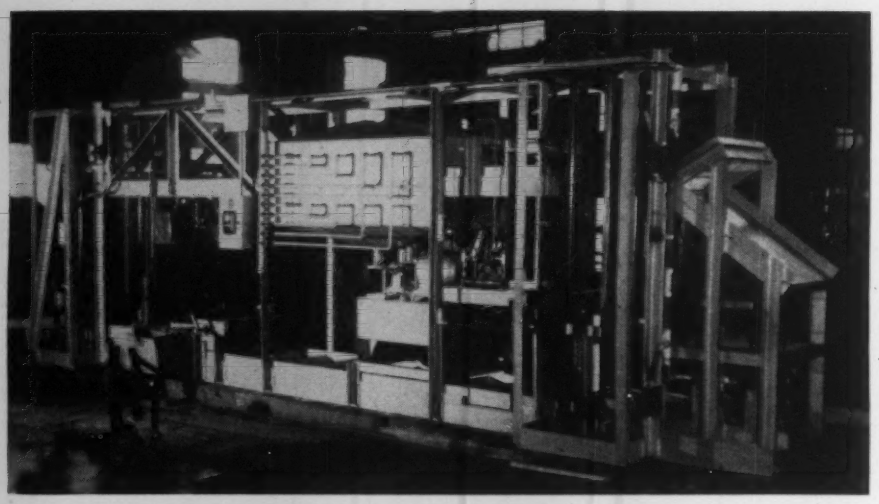
PIONEERS IN AUTOMATION... the design and fabrication of fully automatic material handling systems



This Allied installation maneuvers large steel doors through a production cycle—every phase automatic, all movements synchronized. Magnets hold the door while being up-ended and automatically hung on to a moving conveyor for completing fabrication.

For further information ask for Allied Catalog 953

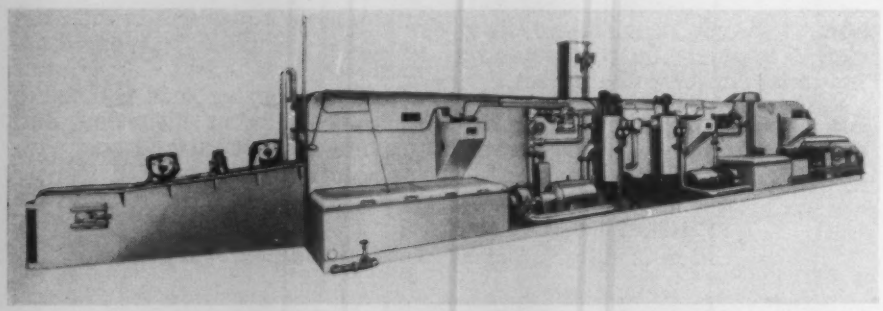
ALLIED AUTOMATION DIVISION
ALLIED STEEL and CONVEYORS, INC.
17377 Healy Avenue, Detroit 12, Michigan



PRODUCTION CASTING AND MOLDING

Tray-Cast machine casts melted ferrous or nonferrous metals, or plastic molding on a forming unit via trays or molds which are easily removed and replaced. One or more pouring stations are incorporated for flexibility in pouring different types of molds at the same time and in changing from one type mold to another. Broken or undesirable molds are easily replaced. A pusher moves the bottom row of trays onto an elevator which moves them to an upper track where another pusher moves them through a cooling chamber and knockout hammer into an ejector. This revolves, knocking the material from the molds. Aluminum, brass, copper, tin, and lead can be cast in capacities from 1000 to 10,000 lb per hour for aluminum, and higher for heavier metals. Machine can be driven electrically, hydraulically, or pneumatically, and timer provides automatic cycling. **Ferguson Equipment Corp.**, 21st St. & Penn Ave., Pittsburgh 22, Pa.

Circle No. **17** *on Reply Card*



AUTOMATIC INDEXING FIXTURE-TYPE WASHER

Three-stage industrial washing machine cleans 400 transmission castings per hour, working on a "pin-point" washing principle instead of the usual cleaning method of passing parts through volume washes. "Pin-point" washing is achieved by high pressure nozzles which are precisely located to clean and flush all passages, such as blind or tapped holes, internally and externally. Pressure removes the chips. A hydraulic indexing drive indexes fixtures into exact position for cleaning, then locks transfer mechanism into immobility for an exact interval until the casting is ready for the next cleaning stage. Control is automatic.

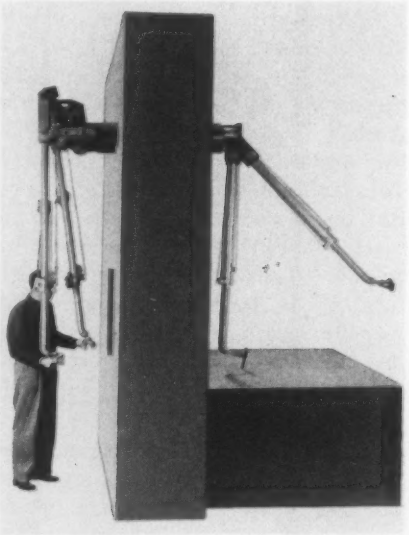
Fixtures have brass pads to hold the casting transmission case and housings in position without any manual clamping. The transfer mechanism is electrically sequenced and hydraulically powered. **International Conveyor & Washer Corp.**, 652 East Fort St., Detroit 26, Mich.

Circle No. **18** *on Reply Card*

MANIPULATOR

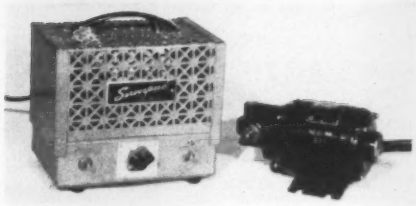
Electrically driven canting mechanism permits angular position of the slave end to be varied independently of the master end in this new manipulator. Operator can bring specimen under analysis to the viewing window without backing away. Mechanism raises slave end to horizontal automatically for easy removal of manipulator arm from barrier wall for repairs or repositioning. Light overhead crane operated by one man can slide the arm from the wall and into a new location in less than five minutes. Combined rigidity and delicacy of touch enables machine to handle loads of 10 to 15 lb effectively in any operation, and loads up to 60 lb can be handled in a straight lift with auxiliary lifting hook.

Each arm weighs approximately 230 lb, is mounted through an 8-



in. diameter opening in the barrier wall at a height of approximately 10 ft. Working area for arms is about 5 ft deep and 8 ft wide at a height of 40 in. from the floor. Statically balanced in all positions so that its weight is not felt, machine has negligible residual unbalance and frictional forces. Radiation sources active in the multi-kilocurie range are handled safely according to current radiation exposure standards. Optional tongs and slave end boots. **Dept. KP, Central Research Laboratories, Inc.**, Red Wing, Minn.

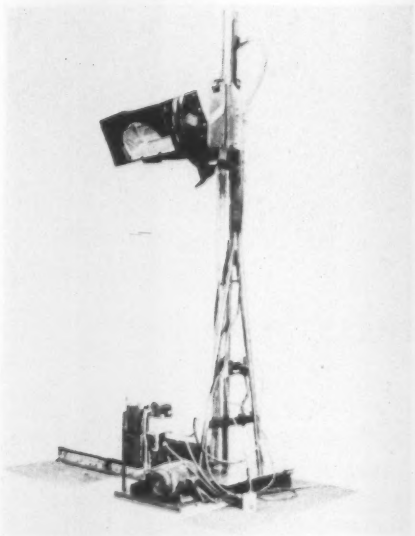
Circle No. **19** *on Reply Card*



MOTOR SPEED CONTROL

Electronic "Servospeed" system is designed for laboratory application to control of sub-fractional horsepower motors. Control system and motors are available from 1/400 to 1/30-hp, with gear-motor ratios from 6:1 to 1120:1 reductions. All base motor speeds are 1750 rpm. Minimum 20:1 speed range is available at constant torque capability to facilitate speed ranges as low as 0.08 to 1.6 rpm in one motor range. **Servospeed, Electro-Devices, Inc.,** 4-6 Godwin Ave., Paterson, N. J.

Circle No. **20** *on Reply Card*



TOTE PAN DUMPER

Fully automatic unit will elevate loaded tote pans to any desired height up to 11-ft above floor level, invert the pan to empty load, and return pan to loading level. Hydraulic hoist is powered by a ¾-hp electric motor. Machine dumps small parts, is ideally adapted to feeding overhead hoppers or conveying systems. As much as 500 lb can be handled per pan. **Allied Sales & Mfg. Co., Materials Handling Div., Grand Specialties Co.,** 3101 W. Grand Ave., Chicago 22, Ill.

Circle No. **21** *on Reply Card*

Digital Computer Techniques

Applied to the design, development and application of

Electronic Business Systems
Military Radar Fire Control Systems
Aircraft Control and Navigation Systems

The successful application of Hughes airborne digital computers to high speed aircraft fire control problems has opened up an entire new area for these digital computer techniques. Similar equipment is now under development in the Advanced Electronics Laboratory to apply such digital computer systems to modern business information handling.

Areas include

LOGICAL DESIGN
COMPONENT DEVELOPMENT
PROGRAMMING
MAGNETIC RECORDING
CIRCUIT DESIGN
INPUT & OUTPUT DEVICES
SYSTEMS ANALYSIS

Hughes *developments in these fields are creating new positions in the Advanced Electronics Laboratory. Exceptional men in the following spheres of endeavor are invited to apply:*

Engineers and Physicists

Computer activities embrace systems planning and analysis, design and development, system engineering and component development. Experience in these areas, as well as in application of electronic digital computers, is desirable but not essential. Analytically inclined men with backgrounds in systems work are required for this phase.

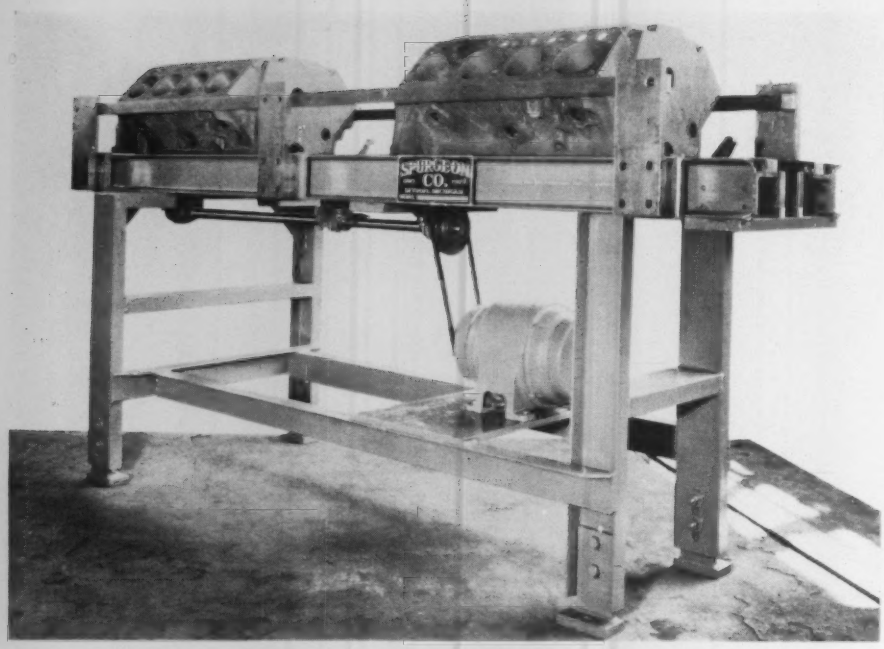
Scientific and Engineering Staff

Hughes

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

Assurance is required that relocation of the applicant will not cause disruption of an urgent military project.



AUTOMATIC TRANSFER DRIVE

Illustrated mechanical drive has been applied to an engine block transfer operating between production machines. The machines move the blocks from one position to another within the machines themselves for the various operations on the block. The "transfer" drive synchronizes the movements of the blocks between the production machines with the machine's movements to give a smooth flow throughout the production line. Line may consist of many machines, all synchronized and connected together by means of these automatic transfers. Drive is made up of a reversing electric motor and a belt connected to a special screw which drives a ball bearing follower connected to a shuttle bar equipped with collapsible dogs to push blocks along the steel ways of the transfer between the production machines. A Varidrive can be installed between motor and screw shaft to furnish variable speeds to the shuttle bar, or motor can be connected directly to the screw shaft. Motor can be connected directly or with Varidrive, belt, or chain on each end of the screw shaft to operate motor in constant and opposite direction with clutches and/or brakes. **Spurgeon Co.**, 23501 Hoover Rd., Detroit, Mich.

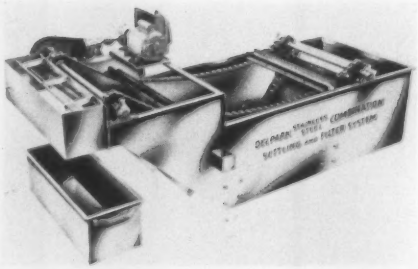
Circle No. **22** *on Reply Card*

sound engineering

lies behind every automation program. Pioneer has a quarter-century of experience with both. No obligation if you'd like to know more.

serving industry since 1931

Pioneer ENGINEERING & MANUFACTURING CO., INC.
Telephone TWinbrook 3-4500
19665 JOHN R, DETROIT 3, MICHIGAN



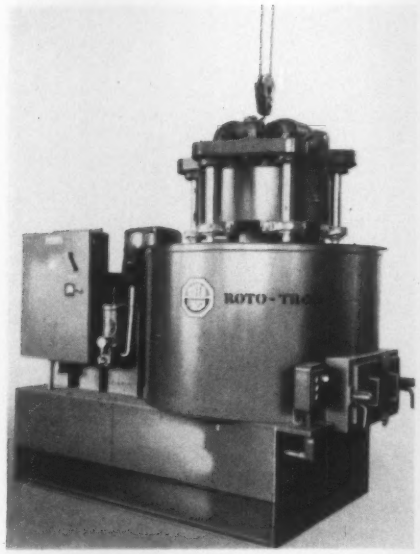
FILTER SYSTEM

Stainless steel settling and filtering system utilizes a settling basin for removal of large particles from liquid prior to filtration through bar stock screens for particles as fine as 0.004-in. System is ideally applied to paper making and food processing industries. Chain driven flights, of solid and brush construction, travel down filter screen removing filtered solids, and then across floor of the settling area gathering additional sediment. Solids are carried up a ramp by the flights, which are automatically cleaned and returned while solids fall into a tote box. Bar stock screens have accurately sized slots to 0.004-in. These screens can be removed for cleaning by sliding solid metal plates behind them and then lifting them out of their channels. **Industrial Filtration Co.**, Dept. SS-471, Lebanon, Ind.

Circle No. **23** *on Reply Card*

METAL FINISHING

Contrary to usual tumbling or barrel finishing processes, a new and completely automatic machine oscillates fixtured parts for a predetermined time cycle through an abrasive media which remains fairly static to obtain high precision finish. Parts must be designed for rigid fixing to withstand pressure when they are forced through the processing. High finish and close tolerances are obtained in brass, steel, and zinc castings and stampings. Jet engine compressor and turbine blades, flame deflectors, escutcheons, knobs, handles, lamp parts, moldings can be handled satisfactorily. Machine is available for

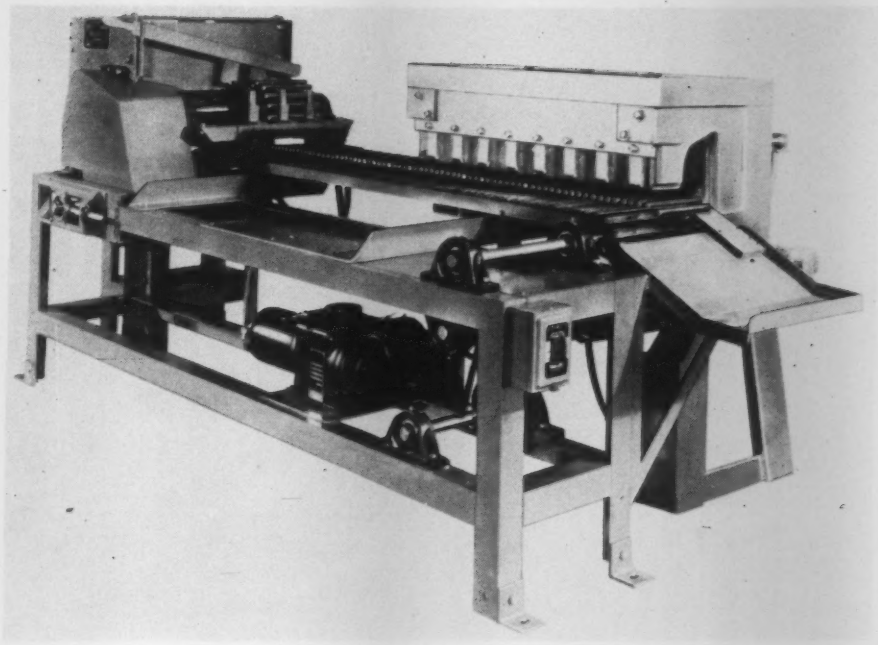


dry or wet processing as required by workpiece and desired finish. Tub in wet processing model has a false bottom which drains accumulating refuse away without disturbing the abrasive. Deeper tub is used for dry processing. **Roto-Finish Co.**, 3700 Milham Rd., Kalamazoo, Mich.

Circle No. **24** *on Reply Card*

BAR STOCK HEATING

A mechanical hopper-feed unit is mounted at one end of a furnace conveyor to supply stock in a completely automatic system for end heating bar stock. Bars can be carried through heat zone at any speed according to desired heating



cycle. Production is said to be increased as much as 100 per cent. Using a furnace with a 39 in. heating zone to heat 2 in. of the end of $\frac{5}{8}$-in. bar stock, system will process 600 pieces per hour. In addition, this automatic procedure features greater heating uniformity and plasticity in the heated metal, minimum floor space, less scale on the end product. **Gas Appliance Service, Inc.**, 1211 Webster Ave., Chicago 14, Ill.

Circle No. **25** *on Reply Card*

SHOCK RESISTANT!

Rivett 3000 P.S.I. sub-plate mounted hydraulic valves

Series 6600 Solenoid Pilot Operated. Furnished in ⅛", ¾", 1", 1¼" and 1½" I.P.S.

Spool features a scalloped design and built-in metering grooves, permitting easier, faster flow and reducing impact. Unrestricted passages allow greater flow capacity—¾" size rated at 28 G.P.M. at 15 ft. per sec.! Four extra long sealing surfaces on the spool provide extremely close fit with valve bore.

FEATURES

1. Continuous duty, shock-mounted solenoids. 3.6 amps inrush; .45 amps holding at 115V.
2. Roomy wiring box. Dust, moisture sealed. ½" conduit connections.
3. 7 spool designs for 3 and 4-way.
4. Less pressure drop.
5. Mounted in any position.
6. Extra long sealing surfaces.

Get new catalog!
Illustrates flow operations for all piston designs. Write today!

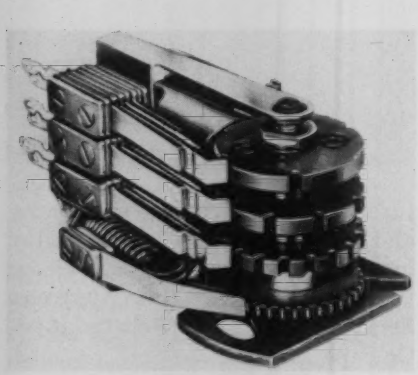
RIVETT LATHE & GRINDER, Inc.
Dept. A-11, Brighton 35, Boston, Mass.

RIVETT furnishes a complete power package

VALVES • CYLINDERS • POWER UNITS

AUTOMATION NEW COMPONENTS

Parts, elements and devices designed for creating more automatic systems



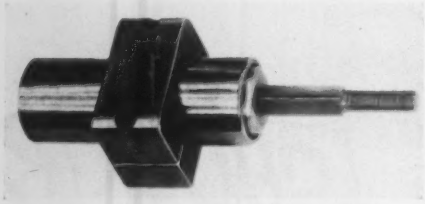
Stepping Switch-Relay

A single cam type rotary relay replaces whole banks of relays or combinations of relays and stepping switches. In addition to being compact and lightweight, the new relay is highly, resistant to shock, vibration, and temperature changes. Weight varies from 14 to 20 oz, depending on particular model. Performance records have exceeded 250,000,000 high-speed operations. Relay can replace delicate latch-in type relays for alternate on-off operations. Fast and accurate for stepping operations, it can be driven self-interruptedly to produce a time cycle or for "homing". **Automatic Electric Sales Corp.**, 1033 W. Van Buren St., Chicago 7, Ill.

Circle No. **26** *on Reply Card*

Clamping Cylinder

A square rod clamping fixture cylinder features a nonrotating piston rod, is ideally suited for use in shops that design their own guide rods for small clamping and locating fixtures. Cylinder is supplied with a 1-in. bore, a 1/8-in. pipe thread air connection, spring return, and 1, 2, 3 and 4 in. strokes. Larger bore square rod cylinders can be furnished. Compact, heavy duty construction and few component parts assure accuracy and long life. Piston rod is supported by a long, oversize bronze bearing, and seal is standard "O" ring. Piston and rod are of chrome plated steel, cylinder barrel and blind end of nickel plated brass, rod end of nickel plated bronze. Mounting block permits adjustment of the cylinder to its full length in the



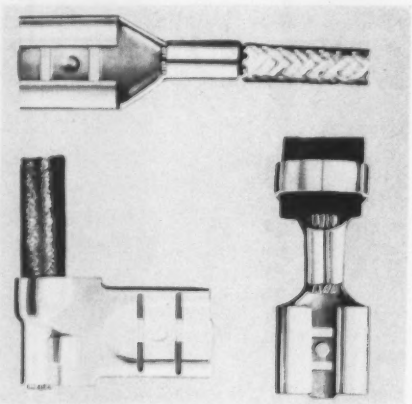
block by adjustment of one screw, thus reducing setup time. **Beckett-Harcum Co.**, 1087 Wayne Rd., Wilmington, Ohio.

Circle No. **27** *on Reply Card*

"Push-On" Connectors

Two new connnectors have been added to company's line of straight-on Faston connectors for smaller wire sizes, #18 through #22, and for insulation support. The former is designed for wire cost reduction programs on non-critical circuits in the manufacture of timer motor leads and appliances.

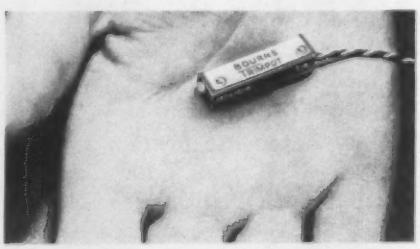
Insulation support connector, used on wire sizes #16 through #12, can handle insulation between 0.210 and 0.265-in. Large size termination is designed for 5/64 and 4/64-in. wall insulation as used in air conditioning and refrigeration. Terminals are available in strip form, may be applied with hand tools as well as automatic machine. Step-down feature between the stripped wire barrel and the insulated wire barrel allows conductor to remain in a straight line after it is crimped. Insulation support barrel will not rupture the insulation upon crimping. **Aircraft-Marine Products, Inc.**, 2100 Paxton St., Harrisburg, Pa.



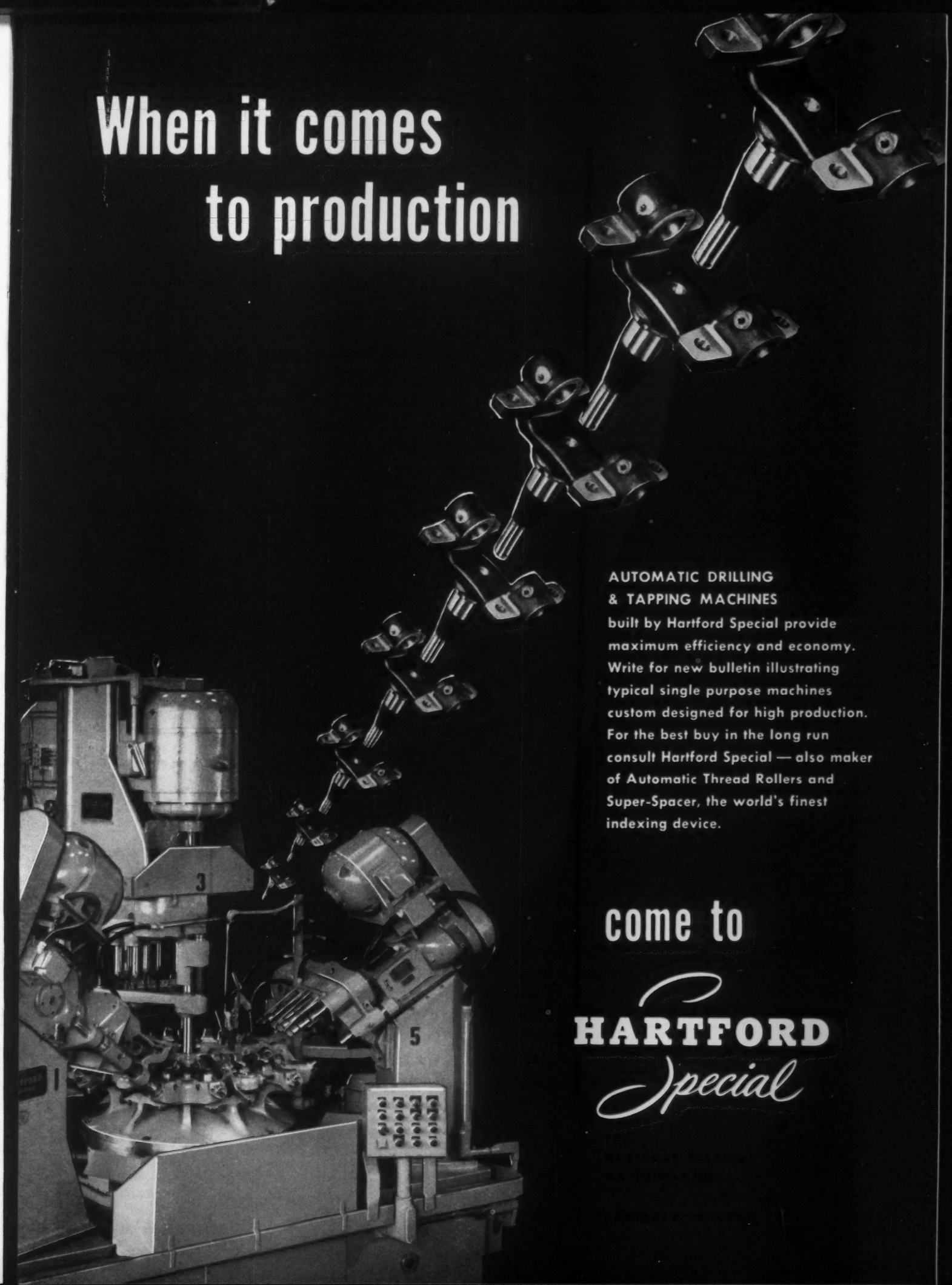
Circle No. **28** *on Reply Card*

Carbon Potentiometer

TRIMpot trims or balances circuits in miniaturized electronic assemblies, has resistance of 20,000 ohms to 1 megohm and infinite resolution. Adjustments of infinite accuracy can be made simply by turning the slotted shaft with a screwdriver. Shaft is self-locking,



When it comes to production

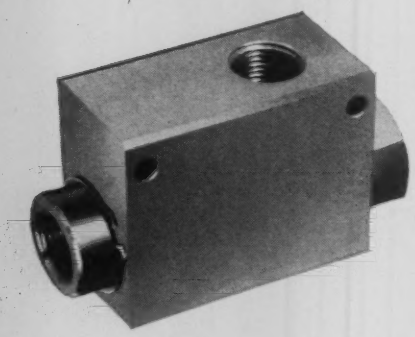


AUTOMATIC DRILLING & TAPPING MACHINES built by Hartford Special provide maximum efficiency and economy. Write for new bulletin illustrating typical single purpose machines custom designed for high production. For the best buy in the long run consult Hartford Special — also maker of Automatic Thread Rollers and Super-Spacer, the world's finest indexing device.

come to HARTFORD Special

requires no lock-nuts. Settings are maintained during extreme conditions of vibration, acceleration, and shock. Instruments may be mounted individually or in stacked assemblies. Special features which can be furnished optionally include dual outputs, special resistances, and extended shafts. Power consumption is 0.2 w, and size is ¼ x 5/16 x 1¼-in. **Bourns Laboratories,** 6135 Magnolia Ave., Riverside, Calif.

Circle No. **29** *on Reply Card*



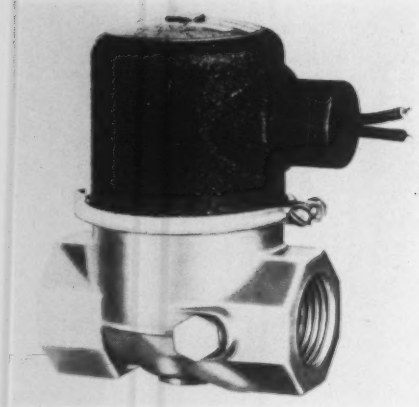
Bypass Flow Regulator

Automatic bypass is featured in a new constant flow regulator. Constant rate of flow can be maintained regardless of variation in pressure or back pressure while simultaneously bypassing excess pump output at working pressure. Bypass at pressure below relief valve settings results in reduced oil temperatures and less frequent oil changes. Regulator is applicable to power steering systems, fluid motors, and any hydraulic system where constant flow is required in the presence of varying pump output. **Waterman Engineering Co.,** 725 Custer Ave., Evanston, Ill.

Circle No. **30** *on Reply Card*

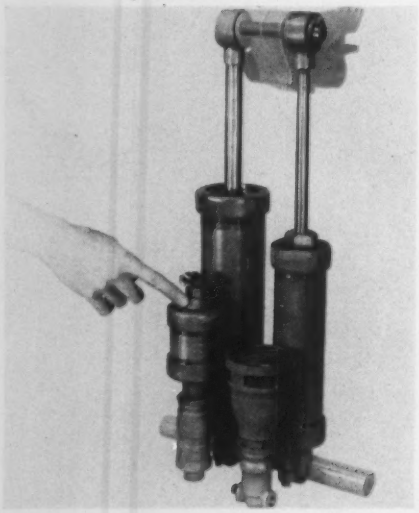
Silent Gas Valve

Magnetic gas valve for gravity and forced air furnaces and unit heaters is free of valve closing impact noise and hum. Valve opens and closes gas lines according to requirements of room thermostats, limit controls, etc. Disk is made of synthetic rubber to settle quietly against valve seat when closed. Model is a soft seated type and has a specially designed solenoid to make it humless. Spring action plus steady pressure of gas brings



the unit into tight shutoff position. Upon interruption of the current, valve closes instantly. Designed for use in company's solenoid control system for 24 v heating control, the new valve can be adapted to thermostatic control of gas-fired appliances, furnaces, boilers, and wall and unit heaters. It is available in sizes from ⅜ to ¾ ips. **General Controls Co.,** 801 Allen Ave., Glendale, Calif.

Circle No. **31** *on Reply Card*



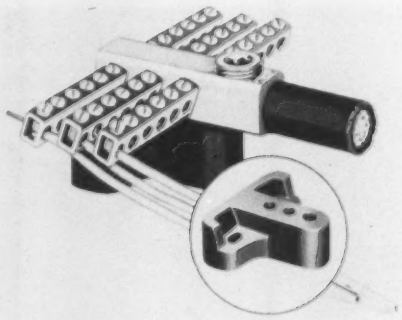
Pneumatic-Hydraulic Power Unit

Speed, damped terminal stopping, powerful finish pressures, and full reversibility are combined in a compact three-cylinder assembly known as the Hydro-Air Power unit. This pneumatic prime mover is applicable to all press work and to the design of machinery and equipment which must close under strong loading. Unit achieves long stroke and fast operation via pneumatic cylinder action, and powerful closing force via the differential hydraulic piston principle. Stroke is 7 in., terminal force is 2100 or 5600 lb, weight is 41 lb, space requirement is less than 1 cu ft, air requirement per cycle is less than 0.11 cu ft. The three cylinders are for (1) a fast, long pneumatic stroke (rear right), (2) a 12:1 hydraulic multiplication of trapped oil pressure for the finishing stroke (rear left), and (3) a trigger action for the high pressure finish stroke (center). This third booster cylinder is available in alternate sizes for regular or heavy duty finish pressure. Main stroke speed is adjusted by regulating air supply pressure. Cycle may be timed manually or automatically by easy treadle, lever, button, cam, or timer arrangements. In press work, the Hydro-Air unit overcomes sacrifice in speed for suitable pressure, large space requirements and difficulty in controlling final pressure application, high pressure steam cost and exhaust disposal, and unduly large cylinder sizes and air consumptions. Standard one-ton model is 16½-in. in overall closed length, heavy duty model is 21 in. **Pantex Mfg. Corp.,** 521 Roosevelt Ave., Pawtucket, R. I.

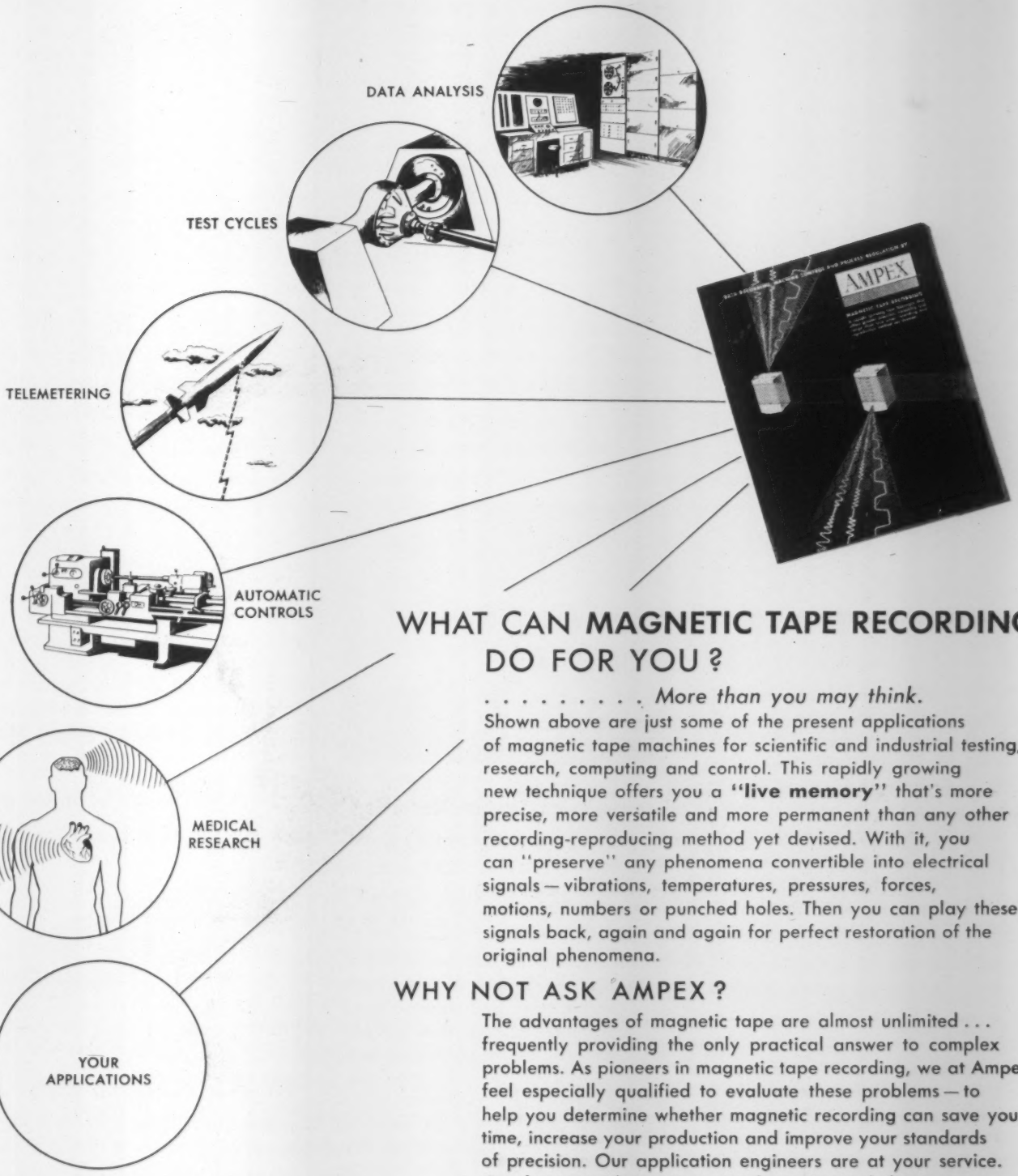
Circle No. **32** *on Reply Card*

Neutral Bar

Circuit bars are forged into main line connectors at a 20° angle for easy wire insertion of every branch circuit wire in a recently developed neutral bar of unusual strength and adaptability. Connections are made parallel to each other with no wires crossing or spreading away from the screw head. There is no necessity for attaching a separate line load connector because the main lug and the circuit bars are forged together. Optional plastic mounting block. **Ilsco Copper Tube & Products Inc.,** Mariemont Ave., Cincinnati 27, Ohio.



Circle No. **33** *on Reply Card*



WHAT CAN **MAGNETIC TAPE RECORDING** DO FOR YOU?

. . . . . *More than you may think.*

Shown above are just some of the present applications of magnetic tape machines for scientific and industrial testing, research, computing and control. This rapidly growing new technique offers you a **"live memory"** that's more precise, more versatile and more permanent than any other recording-reproducing method yet devised. With it, you can "preserve" any phenomena convertible into electrical signals — vibrations, temperatures, pressures, forces, motions, numbers or punched holes. Then you can play these signals back, again and again for perfect restoration of the original phenomena.

WHY NOT ASK AMPEX?

The advantages of magnetic tape are almost unlimited . . . frequently providing the only practical answer to complex problems. As pioneers in magnetic tape recording, we at Ampex feel especially qualified to evaluate these problems — to help you determine whether magnetic recording can save you time, increase your production and improve your standards of precision. Our application engineers are at your service. Or, if you simply want more information, ask for our 16-page illustrated bulletin: "Data Recording, Machine Control and Process Regulation." There's no obligation in either case.

The Signature of Perfection in Magnetic Tape Machines

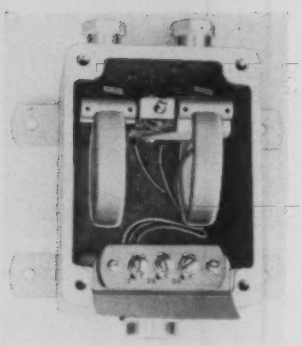
AMPEX CORPORATION

934 CHARTER STREET
REDWOOD CITY, CALIFORNIA

Contact your nearest Ampex representative or write-wire Dept. DD-1711

BRANCH OFFICES: New York; Chicago; Atlanta; San Francisco; College Park, Maryland (Washington, D.C. area).

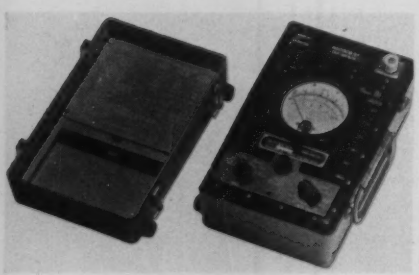
DISTRIBUTORS: Radio Shack, Boston; Bing Crosby Enterprises, Los Angeles; Southwestern Engineering & Equipment, Dallas and Houston; Canadian General Electric Company, Canada.



AC, DC Pressure Switch

Pressure sensitive switch for operating relays, solenoids, motor controls, etc. will sense a pressure difference between two variable pressures or between a variable and a reference pressure. Four classes of proof pressures from 500 to 12,000 psi are available. Circuit can be opened or closed by an increase or decrease in pressure difference of 15 to 10,000 psi at any point within adjustable range of switch. Control of delicate processes and protection of sensitive instruments is repetitively accurate because of two parallel bourdon tube sensing elements. Mechanism requires no balancing or leveling in installation, is adaptable to portable installations. Tamper-proof external adjustment and splash-proof housing permit field setting in exposed locations. Unit has snap action, single pole, double throw switching for ac and dc circuits. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

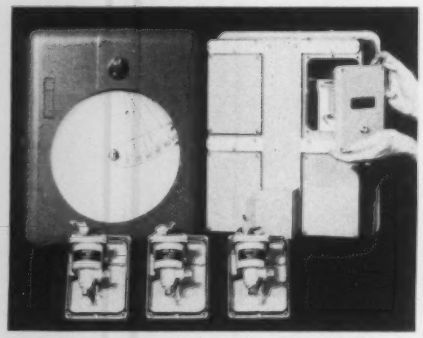
Circle No. **34** *on Reply Card*



Waterproof Multimeter

A waterproof volt-ohm microammeter designed for military use is now available for industrial use. This self-contained testing equipment tests elements of electronic and electric circuits to determine specific electrical characteristics and to check current resistance and voltage in existing circuits. Multimeter features ruggedized, sealed 4½-in. meter, deposited carbon resistors, wire wound resistors, waterproof jacks, and amphenol operating panel which will not exceed 11/100-per cent moisture absorption in 48 hours at 50° C, thus reducing creepage path resistance to a minimum. Case and cover are of die cast aluminum and meter can be immersed in water without cover with no effect on accuracy of the instrument. Meter is adaptable to both ac and dc measurements, is equipped with test leads and accessories. **Phaostron Co.,** 151 Pasadena Ave., South Pasadena, Calif.

Circle No. **35** *on Reply Card*



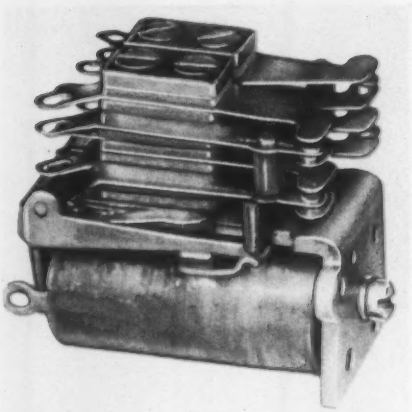
Transmission System Recorder

Receiver recorder indicates any measured variable which can be converted to pneumatic or electric signals in transmission systems in power and process plants. Unit keeps continuous, independent records of one to four transmissions in any combination by means of plug-in, precalibrated receivers. Stainless steel capillary recording pens feed continuously for one year without refilling. Recorder is designed for panel mounting, requires 14 x 17 in. area. **Bailey Meter Co.,** 1050 Ivanhoe Rd., Cleveland 10, Ohio.

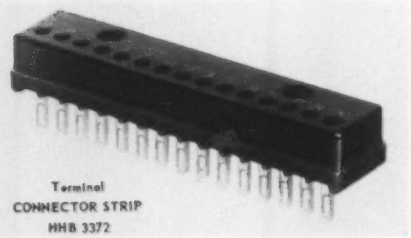
Circle No. **36** *on Reply Card*

Versatile Miniature Relay

Miniature, telephone type relays can be used with communication instruments, electronic control circuits, computers, plate circuits, and remote controls. Designed for low friction loss and extreme vibration resistance at minimum power consumption, relays are rated for 3 amp at 32 v dc, resistive, or 115 v ac, noninductive. Various contact arrangements available include maximum 4-pole, double-throw, 6-pole, double-throw, and make-before-break arrangements. Contacts are of palladium. Maximum sensitivity is 90 milliwatts for single-pole, double-throw, and 750 milliwatts for 4-pole, double-throw. Relays will withstand 10 g vibration up to 55 cycles per second, and 25 g shock. Hermetically sealed relays are available in 9 or 14 pin plug-in or solder terminal models. Size is 1-7/16 x 1-11/32 x 15/16-in. **Leach Relay Co.,** 5919 Avalon Blvd., Los Angeles 3, Calif.



Circle No. **37** *on Reply Card*



Terminal Connector Strip

Female mating strip is designed specifically as permanent base mounting to be used with two series of company's male connectors. Fifteen pressure type sockets of beryllium copper are provided. Nominal creep is 3/32-in. Solder tabs fit No. 20 wire, and plating is gold over silver. Standard insulating material is green mineral filled phenolic, but mineral filled phenolic type MFE, diallyl phthalate MDG, and general purpose phenolic CFG can be provided. **H. H. Buggie, Inc.,** 726 Stanton St., Toledo 4, Ohio.

Circle No. **38** *on Reply Card*

Dynamatic Eddy-Current Units can be put to work in your plant or product

This Free Booklet Will Show You How

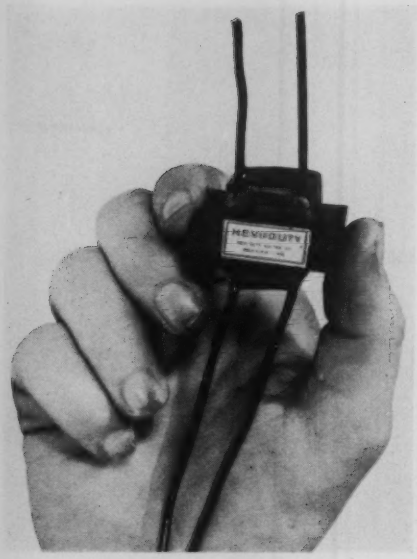
Dynamatic eddy-current couplings, brakes, clutches, dynamometers, and Ajusto-Spede drives, in use today in practically every basic industry in both plant equipment and end products, are proving the ideal solution to difficult speed control and testing problems. Advantages include instantaneous response, infinitely adjustable speed control, wide speed range, quiet operation, low power loss, low maintenance cost, adjustable speed from an AC power source.

Our new booklet "Bulletin GB2" describes and illustrates the basic Dynamatic eddy-current units, including the new stationary field coupling. The text, augmented with illustrations and graphs, describes the basic eddy-current principles and drive characteristics. If you are interested in modern speed control, write for your copy of the new Dynamatic Bulletin GB2.

DYNAMATIC® DIVISION

EATON MANUFACTURING COMPANY

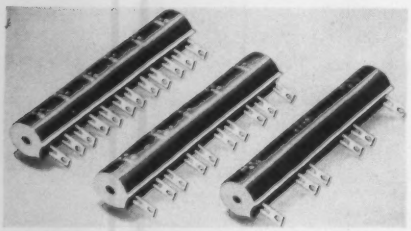
KENOSHA, WISCONSIN • General Offices: Cleveland, Ohio



Panel Board Transformer

Dependable operation of electrical components in all types of control panels is assured by use of a new series of transformers whose compact size suits them ideally to panel use. Sizes start at 2 va. Coils have been precision wound with high dielectric insulation and color coded, 105° C polyvinyl insulated leads are taped to the coils. Slotted mounting feet or a channel type enclosure are available with all sizes. A polymerizing type varnish, resistant to moisture and acid, is used on the transformer. **Hevi Duty Electric Co.**, 4212 W. Highland Ave., Milwaukee 1, Wis.

Circle No. **39** *on Reply Card*



Grouped Capsulated Resistors

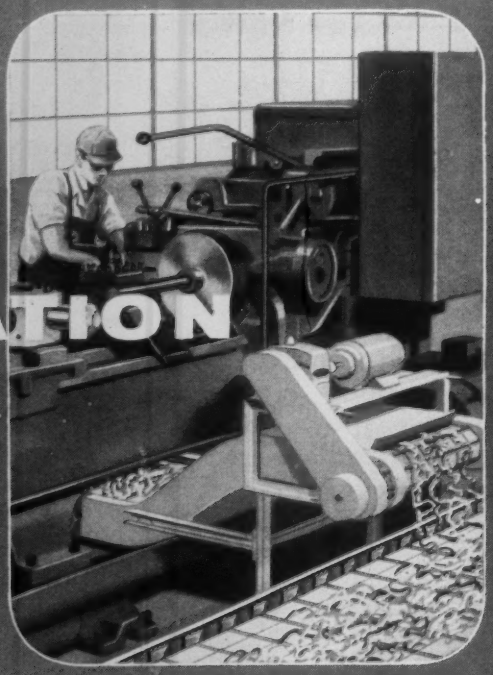
Precision lug-type resistors, enclosed in capsules, are available in "grouped" units of from two to six individual resistors, arranged end to end in a one-piece, molded resin body, Three, five, and six resistor units are illustrated. Specially compounded resin completely encloses each resistor and gives maximum protection against mechanical damage and ambient conditions. Individual resistor units are available in wattage sizes of ¼, ½ and 1 w for 125° C ambient temperature, and in resistance values up to 1,950,000 ohms. Tolerances can be as close as ± 0.1 per cent. Each resistor consists of enamelled alloy resistance wire, non-inductively pie-wound on rigid, steatite bobbins and welded to the terminal for permanently stable electrical connection. **Ohmite Mfg. Co.** 3664 Howard St., Skokie, Ill.

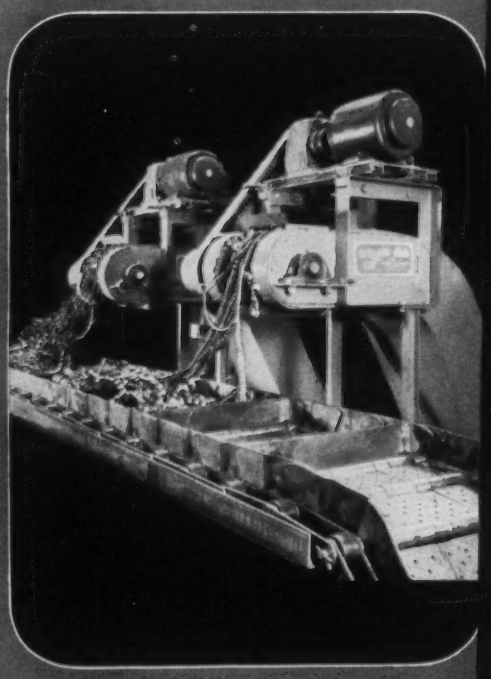
Circle No. **40** *on Reply Card*

Vacuum Gage

Panel mounted vacuum gage gives instantaneous measurement of vacuum in the 1 to 1000 mu Hg range in tests of vacuum pumping and metal vacuum depositing, or in conjunction with vacuum processing equipment. Metal thermocouples in the sensing element are directly heated, therefore reach operating temperature within 0.5

May-Fran
. . . first
for
AUTOMATION
in
scrap
handling
systems





The CHIP-TOTE conveyor permits complete utilization of machine tools by eliminating shut-down for manual scrap removal.

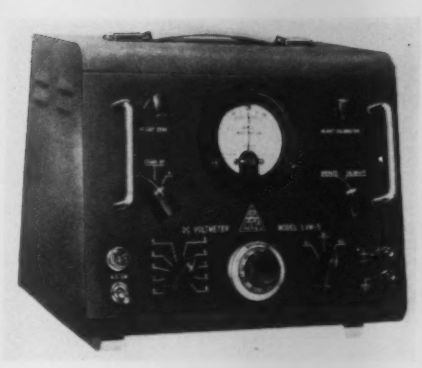
It handles a continuous flow of hot, wet or dry chips, turnings and borings from any multiple spindle automatic machine.

second. Nickel-plated gage tubes afford freedom from outgassing, system contamination and corrosion. Calibration of the gage tubes is not affected by ambient temperature changes or exposure to atmospheric pressure. Instrument is suitable for continuous reading or recording, measures 7 x 7½ x 2¼-in., and weighs 3½-lb. **Hastings Instrument Co., Inc.,** Warwick, Va.

Circle No. **41** *on Reply Card*

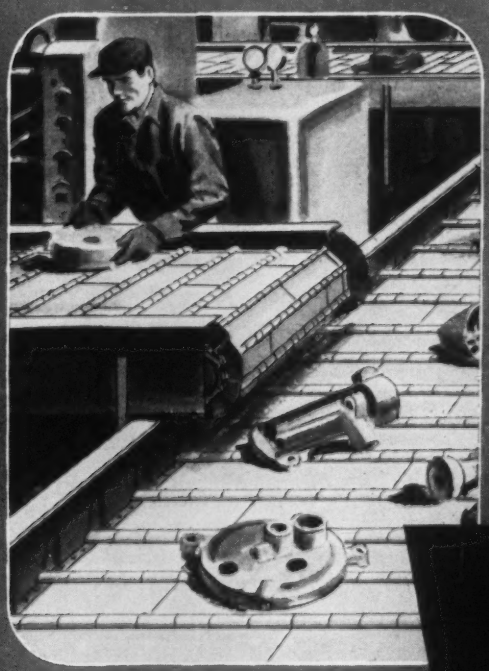
High Resolution Voltmeter

New laboratory standard voltmeter employs the nulling principle to achieve high resolution and accuracy and infinite input impedance over a wide range of voltage measurements, including extremely low dc voltages. Voltage range is 0 to 100 v dc, and resolution is at least 50 mu v up to 1 v, at least 500 mu v up to 10 v, and at least 5 mv up to 100 v. Accuracy is within ±0.1 per cent of reading, and linearity is better than 0.05 per cent. Instrument can be used as an electronic null indicator, as a comparison bridge, or as a current meter. Because of its ruggedness, ease of operation, and portability, it can be used for production line testing and field use. It will measure computer voltages, power supply regulation, electrochemical potentials. It can also calibrate meters, transducers, and strain gages, and can adjust voltage sources to specified values. In operation, the voltage to be measured is compared with the output of a precision attenuator



across a highly stable internal supply. The difference voltage appears at the input of a high gain chopper amplifier. After phase-sensitive detection, this amplified signal is applied to a null indicating panel meter. Precision attenuator is then adjusted for zero deflection on the null meter. At this point the two voltages are identical, and the value of the unknown may be read directly from the attenuator setting. **Computer Co. of America, Div. of Bruno-New York Industries Corp.,** 149 Church St., New York 7, N. Y.

Circle No. **42** *on Reply Card*



Now is the time to put AUTOMATION to work . . . Now is the time to cut production costs . . . May-Fran engineers design and build complete scrap handling systems for the automatic removal of machine turnings or chips. May-Fran conveyors will transmit scrap to ultimate point of disposal.

Press Scrap systems can be made completely automatic. Hinged-steel belt will take scrap from presses, handle it through blanking, shearing, forming and baling processes, and deliver it to rail cars.

May-Fran is prepared to engineer, fabricate and install complete conveyor systems to your specifications.

Write today for complete information on how an automatic scrap removal system will cut your production costs.

Bulletin MF-530 describes the new Hinged-Steel conveyor belt.

Bulletin MF-640 describes the Chip-Tote conveyor which removes scrap from operating machines.

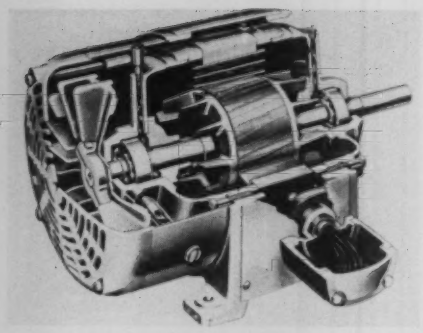
Hinged-steel belting handles scrap as well as hot heavy and abrasive castings. Belt is economical . . . maintenance-free.

DESIGNERS AND ENGINEERS OF COMPLETE SCRAP HANDLING SYSTEMS

MAY-FRAN ENGINEERING, INC.

5003-MF

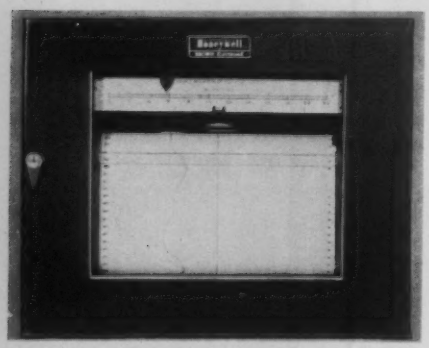
1761 CLARKSTONE ROAD
CLEVELAND 14, OHIO



Motor for Chemical Service

Specially designed for chemical applications, this new motor is totally enclosed and protected against corrosion for use in dangerous or damaging atmospheres. Motor features a stainless steel fan cover guard and a stainless steel stator band surrounding the inner enclosed case. A cast iron conduit box, sealed with a nondeteriorating, impervious compound, and a cast iron ventilating fan, are provided, or a cast bronze fan for explosion-proof service. Cadmium plated screws and fittings, elongated bearing caps, normalized bearings, and a double sealed moisture drain are featured. Windings are asbestos protected, and lubrication is transverse. Motors may be furnished with ratings from 3 to 150 hp. **U. S. Electrical Motors Inc.,** Box 2058, Los Angeles 54, Calif.

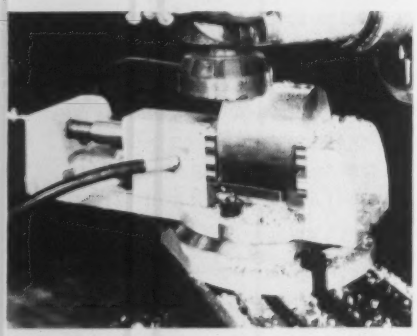
Circle No. **43** *on Reply Card*



Extended Range for Recorder

Electronic strip chart recording instrument couples a single scale with automatic range extension to extend measuring range by five equal suppression steps. This increases effective length of scale and measuring slidewire to five times that of single-range instruments with the same total measuring span. Readability of chart is increased proportionally. Pen speeds are 2 or 4½-seconds for full scale travel, and basic chart speeds are 6, 30, and 120 in. per hour. Minimum span is 2.2 mv. Four additional suppression steps of 2 mv each are automatically switched into or out of the measuring circuit to meet varying requirements and provide a total minimum range of 10.2 mv. Recorder is especially adaptable to measurement of any linear condition where the values vary throughout a wide range yet still require precise measurement, as in projectile stress testing in wind tunnels at supersonic speeds. **Minneapolis-Honeywell Regulator Co., Industrial Div.,** Wayne & Windrim Aves., Philadelphia 44, Pa.

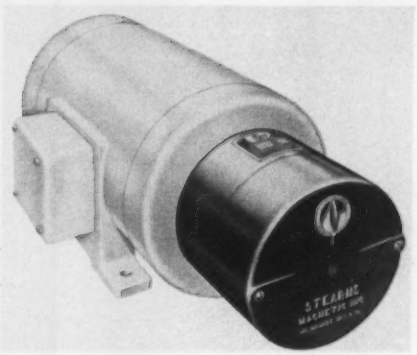
Circle No. **44** *on Reply Card*



Air Powered Hydraulic Vise

New milling machine vise, called the WiltOmatic M-M, combines the speed of an air vise with the strength, compactness, and locking force of a hydraulic vise to meet industry's need for an automatic machine vise. Fixture is expected to cut loading and unloading time by as much as 80 per cent, as well as eliminate expensive special production tooling when it is used as an automatic holding fixture with specially formed jaws. Touching off the air valve footswitch instantaneously places a 9000 lb force on the jaws of the vise, yet tool is flexible and adjusts with ordinary crank handle motion to any desired opening. It can be locked manually or automatically. Swivel base is optional. Normal air line pressure of 90 lb is recommended, but vise functions on any air pressure from 20 to 140 psi. **Wilton Tool Mfg. Co. Inc.,** 925-941 Wrightwood Ave., Chicago 14, Ill.

Circle No. **45** *on Reply Card*



Disk Brake for Re-Rated Motors

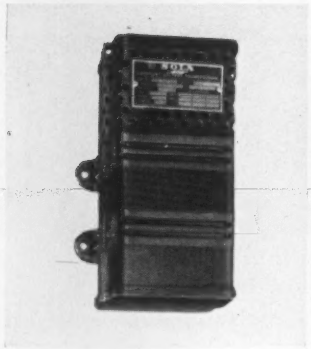
Designed for use on re-rated 3 to 20 hp motors and for mounting on new 213 through 286 frame sizes, a magnetic disk brake is almost 1 in. shorter than similar previous brakes. Maximum torque ratings available are 10, 15, 25, 35, 50, 70, 75, and 105 lb-ft. This spring set, solenoid released brake is furnished for horizontal or vertical motor mounting, or for independent floor mounting. Enclosure may be standard or dust tight and waterproof. Brake is equipped with a new manual release, automatic reset wear indicator. **Stearns Magnetic, Inc.,** 635 S. 28th St., Milwaukee 46, Wis.

Circle No. **46** *on Reply Card*

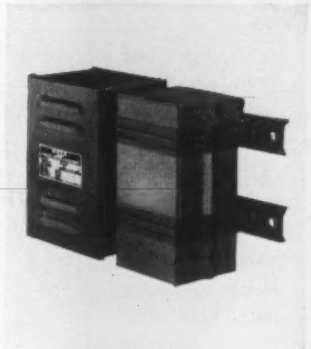
Open Link Conveyor Belt

A new belt conveyor with an open type link is readily adapted to annealing, normalizing, stress relieving, and operation in draw furnaces where circulation of the heat in the furnace is essential. Conveyor operates in temperatures up to 1800° F, comes in widths of 18 to 60-in., and adapts to long spans. It can be used with currently operating drums, and rail and roller supports made by the same company. Newly designed open type link features extra heavy hinge sections for long life, and is easily and quickly replaced when necessary. **Standard Alloy Co., Inc.,** 1679 Collamer Rd., Cleveland 10, Ohio.

Circle No. **47** *on Reply Card*



STANDARD TYPE CV
Twenty-nine units from 15va to 10kva in a common power line and filament voltage ratings . . . regulation ±1% or less with a total primary variation of 30% . . . for electronic and electrical equipment requiring close regulation.



HARMONIC-NEUTRALIZED TYPE CVH
Six units from 60va to 2kva . . . input range 95-125v, output 115v . . . all the features of the Standard Type CV plus a harmonic neutralizer circuit . . . ±1% regulated voltage with less than 3% harmonic distortion.

ADJUSTABLE, HARMONIC-NEUTRALIZED TYPE CVL
Two ac voltage supply units, 250va and 500va . . . input range 95-125v, output range adjustable from 0-130v . . . regulated ±1%, harmonic distortion less than 3% . . . for general lab work, testing and other applications.

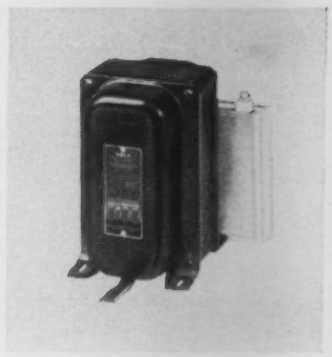
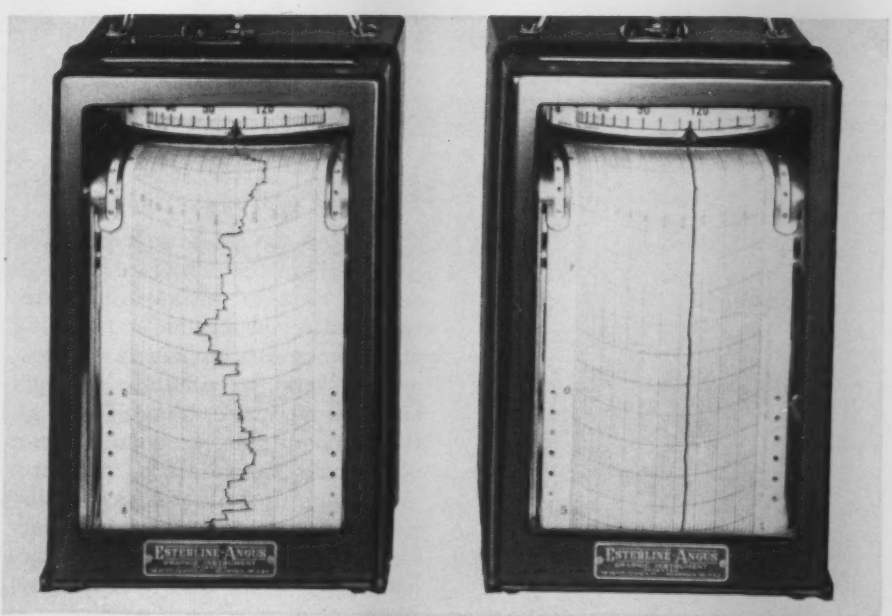


PLATE AND FILAMENT TYPE CVE
Three units in popular power supply ratings . . . a single, compact source of filament and plate supply voltages . . . regulated to within ±3% or less with line voltage variations of 100-130 volts . . . supplied with separate capacitor for chassis mounting.

±1% stable voltage for automatic control equipment regardless of line voltage variations up to 30%

The voltage-critical elements of electronic and electrical equipment for automatic control cannot operate to performance specifications in face of input voltage fluctuations. Stable input voltage can be easily provided with a Sola Constant Voltage Transformer . . . built in as a component, or used externally as an accessory.

Among the chief advantages of Sola regulators are: continuous, automatic regulation . . . response time 1.5 cycles or less . . . no moving or expendable parts . . . immediate availability of 40 stock units . . . and custom units to your specifications in production quantities.

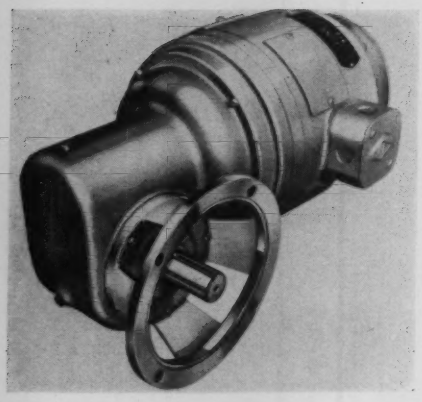


TYPICAL EXAMPLE OF SOLA VOLTAGE REGULATING ACTION. The recording on the left represents a fairly common condition of voltage fluctuation on a 115v line. The chart on the right was made at exactly the same time from the same line. The primary of the Sola regulator was fed the voltage charted on the left, the voltage charted on the right represents its secondary output, regulated to within ±1% of 115v.

SOLA *Constant Voltage* **TRANSFORMERS**

Write for a 28 page bulletin with complete electrical and mechanical specifications on these Sola units. Request BULLETIN 25K-CV-200.

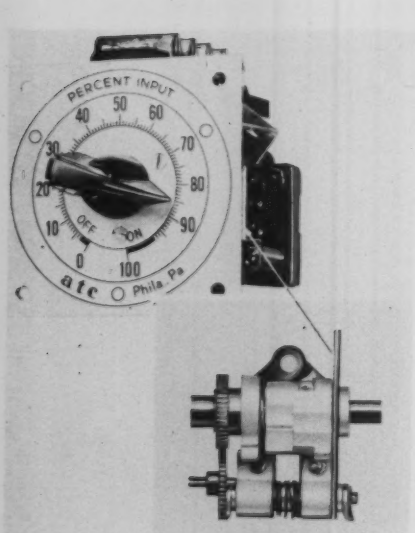
CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO., 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414** • *BOSTON:* 272 Centre Street, Newton 58, Massachusetts • *NEW YORK 35:* 103 East 125th Street • *LOS ANGELES 26:* 2025 Sunset Boulevard • *PHILADELPHIA:* Commercial Trust Building • *CLEVELAND 15:* 1836 Euclid Avenue • *KANSAS CITY 2, MISSOURI:* 406 West 34th Street • *Representatives in Other Principal Cities*



Fluid Cushioned Speed Reducer

Fluid cushioned starting and worm type speed reduction are designed into a new unit for powering loads which require smooth and gradual acceleration (mixers, conveyors, centrifugals). Ring or foot mounting is possible in 16 different positions for installation in tight or inaccessible places. Reducers are available in ⅓ and ½-hp, ¾ and 1-hp, 1½-hp and 2-hp models in correspondingly larger frame sizes. Speed reductions are from 24 to 140 rpm. **Reuland Electric Co.,** Alhambra, Calif.

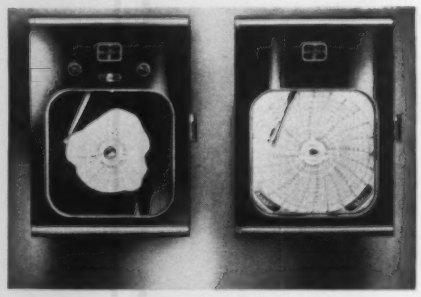
Circle No. **48** *on Reply Card*



AC Circuit Interrupter

Interrupter provides stepless temperature control of electric ovens, furnaces, driers, evaporators, and dehumidifiers without the use of rheostats by providing cyclic interruption of full ac line circuit according to "on" time selected. If dial is set at 50 per cent, a one-minute cycle puts power on 30 seconds and off 30 seconds, while setting of 25 per cent calls for 15 seconds on and 45 seconds off, etc. Full range from zero to 100 per cent is calibrated on dial. Timing cams and contact arms are made of precision molded nylon to reduce wear, noise, and friction. Oiled-for-life rotor on the synchronous motor eliminates need for lubrication. The selector knob maintains its setting by means of a heavy wire spring stressed against the dial cam to absorb vibration. Heating loads up to 4.6 kw can be handled without the use of external contactors. Unit is available unenclosed or in explosion-proof housing with external dial which can be surface or flush mounted. **Automatic Temperature Control Co., Inc.,** 5200 Pulaski Ave., Philadelphia 44, Pa.

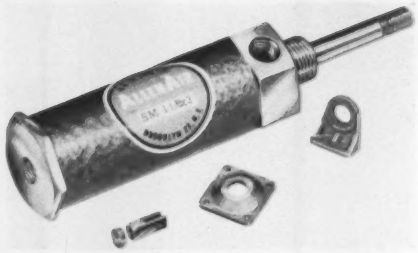
Circle No. **49** *on Reply Card*



Testing Program Controller

Line of control instruments for use in environmental test cabinets can be used to initiate and maintain entire programs of varying climatic conditions within the test cabinet, and to simulate any desired temperature, humidity, or altitude conditions. Instruments can also bring temperature, pressure, or vacuum up to any desired value and maintain it for a predetermined length of time. Control accuracy is ½-per cent of full scale value. Controllers are available in one or two case models, with electric on-off or proportional input control, or with pneumatic control in proportional, reset, or derivative modes. Two-case models mount one above the other or side by side to suit cabinet requirements. Plastic or aluminum cam acts as template for program, and can be changed in seconds for another cut to a different program. **Bristol Co.,** Waterbury 20, Conn.

Circle No. **50** *on Reply Card*



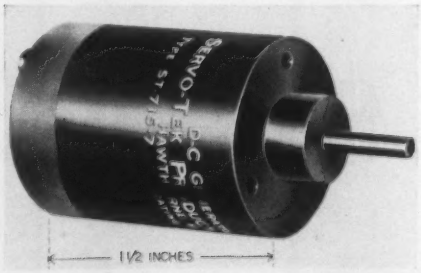
Air Cylinders

New line of Studmount cylinders has 1⅛ bore with strokes in inches and half-inches from 1 to 6-in. maximum. Double acting cylinder has nickel plated brass heads which are screwed into the honed and "Copper - brited" cylinder tube. Stainless steel piston rod is screwed and brazed to the brass piston. Standard "O" rings seal both piston and piston rod. Flange, foot, and piston rod clevis mounts are available. **A. K. Allen Co.,** 57 Meserole Ave., Brooklyn 22, N. Y.

Circle No. **51** *on Reply Card*

DC Tachometer Generator

A permanent-magnet field assembly is incorporated into a new line of tachometer generators. These units are used principally as rate generators, but can be combined with standard voltmeters as direct-reading tachometers. In addition, they may be used as under or over-speed indicators, as synchronizers of rotating machinery, and as speed synchronizing controls. Generator has aluminum housing, low-torque ball bearings, and anodized finish. Output voltage is controlled to within 1 per cent of the same value for either direction of rotation. Available outputs are 2.5 and 7 v per 1000 rpm. Flange mounting arrangement is usually used, and a synchro type mount is available if desired. **Servo-Tek Products Co. Inc.,** 1086 Goffle Rd., Hawthorne, N. J.

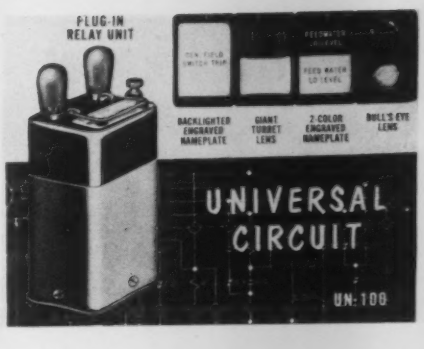


Circle No. **52** *on Reply Card*

Pressure Transmitter

Potentiometer is isolated from actuating pressure in a small, rugged, potentiometer type pressure transmitter with pressure range of 15 to 80 psi. Primarily an absolute pressure instrument, gage and differential pressure models are available for operation by both atmospheric and fluid pressures. Sensitive bellows moves brushes of one or two precision potentiometers, and output is linear with pressure. Resistances of 2000 to 15,000 ohms can be furnished, with 5000 and 10,000 ohms considered standard. Operating range is −50 to 90° C. Weighing only 8-oz, unit measures 2-in. in diameter and 2½-in. long. Adaptations are to aircraft and missile control circuits, air computers, altitude or air speed measurement, pressure telemetering and industrial control. **Genisco, Inc.**, 2233 Federal Ave., Los Angeles 64, Calif.

Circle No. **53** *on Reply Card*



Relays for Annunciators

Plug-in relay unit can handle over 100 signalling sequence operations, can accommodate either normally open or normally closed field trouble contacts, and can be changed easily for maintained or momentary service while in the field. More than 100 standard circuits are available, many with wiring which permits variation in circuits by simple changes in the terminal wire connections. "Unitized" construction facilitates assemble into any number of multiple alarm stations from a single unit to many hundreds. Complete annunciator systems can be supplied from a single unit with all stations being served by a common acknowledging pushbutton and a common sound device. Relay plug-in units can be used with annunciators employing illuminated nameplates and turret lenses, or remote lamps, as well as 2-color split and bull's-eye lenses. Cam operated heavy duty motor driven flashers can be used with either hermetically sealed or general purpose units. Flasher either occupies one station in the annunciator chassis or is mounted on back of annunciator cabinet. **Tigerman Engineering Co.**, 4332 N. Western Ave., Chicago 18, Ill.

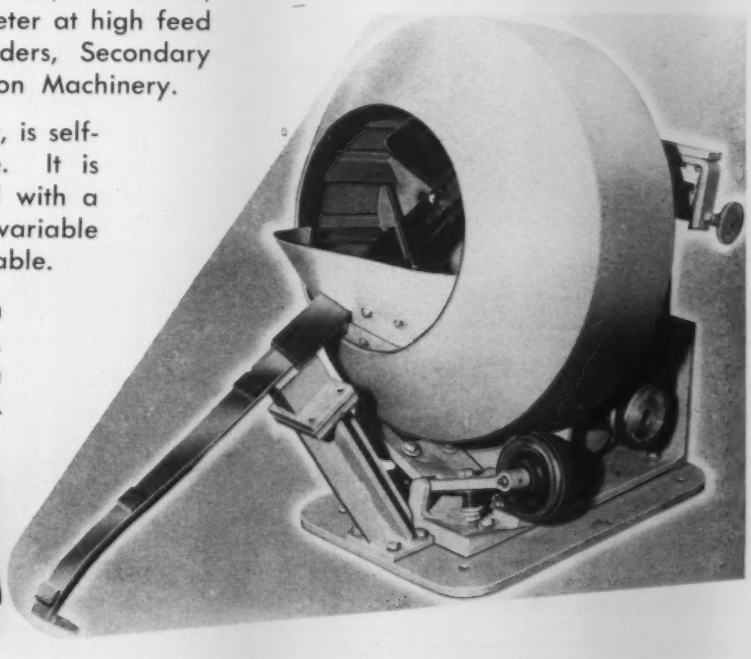
Circle No. **54** *on Reply Card*

SPEED UP PRODUCTION WITH FEEDALL HIGH SPEED AUTOMATIC PARTS FEEDER—

This Model 400 Tumble Hopper will feed Washers, Nut Blanks, Nuts, Special Stampings, etc. up to ½" diameter at high feed rate to Assembly Presses, Centerless Grinders, Secondary Operation Machines or other High Production Machinery.

The Model illustrated is 24 inches in diameter, is self-contained and is mounted on a flat base. It is rigidly built for high production, is powered with a ¼ H.P. 3-phase motor and equipped with a variable speed drive. Two smaller models are available.

FEEDALL Automatic Feeders are made with Hopper, Rotary, Vibratory or Blade Feeds. Send samples or prints with your production requirements and let us tell you how FEEDALL can help you.



FEEDALL
MACHINE AND ENGINEERING CO.
WILLOUGHBY, OHIO, U.S.A.

ELECTRONIC ENGINEERS

North American's Aviation Missile and Control Equipment Department offers unusual opportunities for engineers in the following fields:

FIRE CONTROL SYSTEMS
RADAR
ANALOG & DIGITAL COMPUTERS
INSTRUMENTATION
TRANSISTOR CIRCUITRY
SERVOMECHANISMS
SYSTEM TESTING

Openings exist at both senior and junior levels. BS, MS or PhD in Mathematics, Physics or EE required. Junior engineers with this educational background, without experience, will be accepted for training in the above openings.

For additional information please forward resume to:

Missile & Control Equipment Dept. A, Engineering Personnel

NORTH AMERICAN AVIATION, INC.
DOWNEY, CALIFORNIA

In the N. Y. area, please contact our representative, Mr. G. W. Benedict, 19 Rector St., Rm. 1609, N. Y. 6, N. Y.

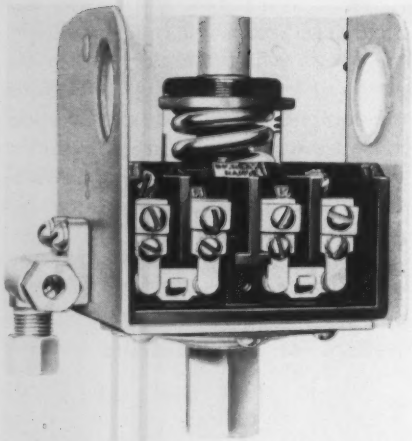
what article

in this issue would you like to have in your file? Just circle the page number on the reply card* and we'll do the rest.

*

THIS SERVICE IS FREE.

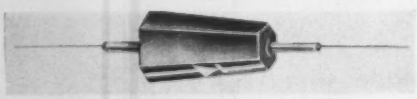
See page 99.



Pressure Switch

Isolation of electrical from mechanical units is featured in a heavy duty pressure switch which is ideally applied to industrial and service station air compressors and domestic water pumps. Wiring cannot interfere with working parts of the switch. All parts with bearing surfaces are of stainless steel, and all other operating parts are of plated steel or a noncorrosive material. Diaphragm is of nylon reinforced neoprene, and contacts are silver alloy and highly resistant to welding. Looping wire or using lugs or grommets is unnecessary. Skinned wire is simply inserted and tightened with screw driver. "Straight through" wiring is accomplished by conduit openings for a ½ or ¾-in. conduit on each side of the case. Operating range and differential are set at factory to buyer's specifications, can then be adjusted with a screw driver and small wrench. **Cutler - Hammer, Inc.**, 315 N. 12th St., Milwaukee 1, Wis.

Circle No. **55** *on Reply Card*



Germanium Diodes

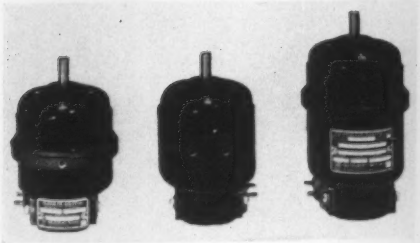
Two functions are covered by six new germanium diodes recently added to company's regular line. One model, the Video Detector Diode, is designed for use in television receivers. The other five models are recommended for 55° C operation where stability and long life are required, such requirements as might be encountered in computer applications. These diodes have passed severe tests in the quality control department and are said to give good performance over long periods of constant use. Wax impregnation of interior vacuum protects diode against fumes and moisture. **Seletron & Germanium Div., Radio Receptor Co., Inc.**, 251 West 19th St., New York 11, N. Y.

Circle No. **56** *on Reply Card*

Fast Analog-Digital Converter

When used with data handling systems or digital computers this new converter simplifies and speeds up analog-digital conversion by eliminating ambiguity and intermediate analog steps. Two pick-off brushes are used for each track of the code disc, except the first, to erase ambiguity. Signal travels from shaft to code discs to either a relay system or diode scanning network followed by a single flip-flop. While discs are made for binary operation, other systems may be ordered. Control circuits can share time for multicontrol systems by using isolation diodes in series with each pick-off brush for scanning many converters. Digit output frequency runs from 500 cycles to 1 megacycle or more, and normal operating expectancy of unit is 5 million cyclings at a rate of 1-2 rps. Weighing 8 oz, the converter measures 2-in. diam and approximately 2½ to 5-in. long. Models are available with 7, 13, 17 and 19 digit units. **Librascope, Inc.**, 1607 Flower St., Glendale, Calif.

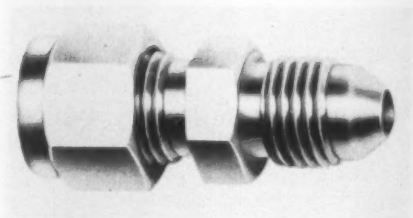
Circle No. **57** *on Reply Card*



Tachometer-Generators

Permanent magnet dc tachometer-generators are available in two sizes and in three frames: M-22 and M-24 frames for flat and flange mounting, respectively, with 1 v output per 100 rpm; L-24 for both flat and flange mounting, with 3 v output per 100 rpm. Tolerance on output voltage is ±10 per cent in all models, and output at constant ambient temperature is lineal ±1 per cent with speed. Speed range is 50 to 5000 rpm, and output is constant within ±5 v for rotation in either direction at constant speed. Frame is of aluminum, shaft of stainless. Units have 11-slot armatures and commutators and vacuum impregnated Formvar type windings. M-22 and M-24 models are 3⅛-in. long, 2¼ and 2½-in. in diameter, while L-24 is 4-in. long, with diameter of 2½-in. Shafts extend ⅝-in. **Instrument Motors,** Box 5, Stamford, Conn.

Circle No. **58** *on Reply Card*



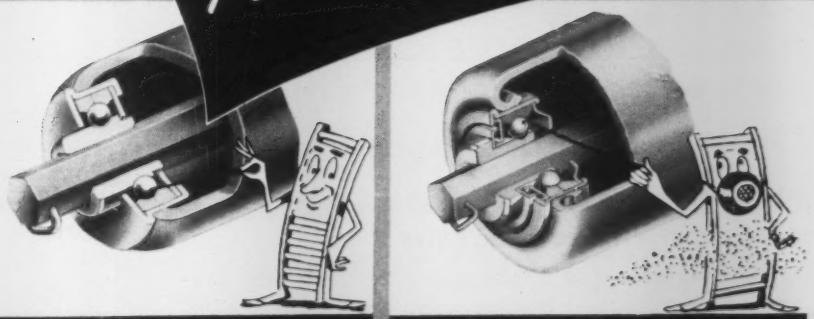
Flare Connector

A new flare connector has been added to Swagelok tube fittings for easy changeover from flare fittings to tube fittings. Connector has proven satisfactory for both testing and permanent installations. Torque-free, leakproof seals are featured for all connections. Complete range of sizes is available from ⅛ to 1-in. in brass, aluminum, steel, stainless steel, Monel, and other machinable metals. **Crawford Fitting Co.,** 884 E. 140 St., Cleveland 10, Ohio.

Circle No. **59** *on Reply Card*

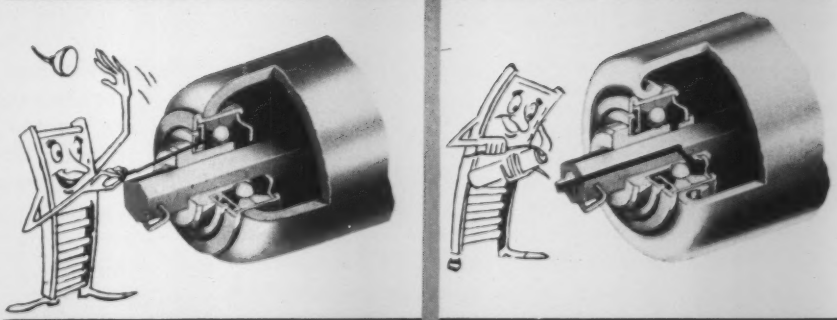
Better Built

BUSCHMAN ROLLER CONVEYORS *Feature:*



Plain Ball Non-Lubricated Bearings

Dustproof Labyrinth-Sealed Bearings



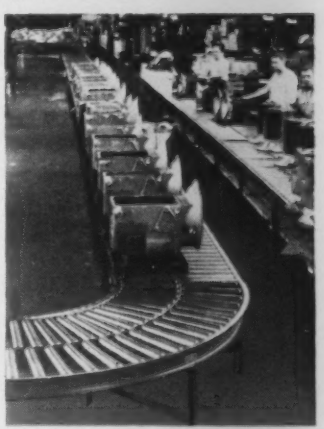
Grease-Packed-For-Life Bearings

or Pressure Lubricated Bearings

TO MEET YOUR REQUIREMENTS

In roller conveyors, it's the bearing that counts! And BUSCHMAN conveyors use only performance-proven bearings... engineered for long life and trouble-free operation in every type of service. No matter what normal operating conditions may be, BUSCHMAN has a conveyor pre-engineered to meet your needs.

Conveyors are available with various types of rollers and frames, in different sizes and spacings, and in any width from 6 inches on up. BUSCHMAN can supply 45° and 90° curved sections, switches, spurs, work stations and other components to provide a complete, efficient materials handling system.



For Complete Details, Write For 16-page Catalog No. 60 Today.

PRODUCE MORE ... FOR LESS on Buschman Conveyors

C-113-EWB

THE E. W. BUSCHMAN COMPANY
4544 Clifton Ave. • Cincinnati 32, Ohio

COMPLETE CONVEYOR SYSTEMS FOR ALL TYPES OF INDUSTRIES • ENGINEERED • MANUFACTURED • INSTALLED
Representatives in Principal Cities • Canadian Licensed Manufacturer: J. A. McKechnie, Ltd., Toronto

AUTOMATION

PATENTS

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Controls

FOLLOW-UP TYPE CONTROL VALVE

Transmitter for a pneumatic telemetering system incorporates measurement and differential members, bell cranks, bellows, pilot valves to the end that the pilot valve couple assumes a null position when a predetermined fluid pressure exists in the expansible-contractible chamber for each position of the measuring member. Patent 2,675,015 by Harvard H. Gorrie, assigned to Bailey Meter Co.

CHECK VALVE

Opposite terminal ports with intermediate valve chamber, tapered nosed valve member so shaped that when inlet pressure forces valve from seat annular spring chamber is sealed off from entry of fluid passing through valve. Patent 2,675,021 by Frederick A. Allin, assigned to Weatherhead Co.

CONTROL SYSTEM AND CARRIAGE MOVING MEANS FOR FLYING CUTOFF APPARATUS

Cam means operated by tube mill accelerates carriage to speed synchronous with the tubing to which carriage is then clamped, whereupon the cutting means severs tubing while continuously advancing. Independent arrangement returns carriage to pick up next length. Patent 2,675,076 by Halton A. Billetter, assigned to McKay Machine Co.

TENSION CONTROL FOR TRAVELING STRIP MATERIAL

Compressed air under uniform pressure is fed to pneumatic braking means. Device between supply spool and withdrawing mechanism is movable in response to variations in tension and connects to brake in such a manner as to bleed off a portion of the air and vary the retarding effort. Patent 2,675,191 by George P. McGraw, Jr., assigned to Western Electric Co.

• • •

Data Processing

HIGH-SPEED REPERFORATOR

Means for continually and cyclically actuating the punching mechanism to perforate a tape. Means to preclude associated punching means from action and electromagnetic arrangement to cancel out the precluding. Means for advancing the tape in proper timing with the punching. Patent 2,675,078 by Walter J. Zenner, assigned to Teletype Corp.

CODING AND DECODING DEVICES FOR STATISTICAL MACHINES

Coding device has means to sense data representations of numerals from a record, and actuated coding elements to transmit impulses of code representation of the numerals. Decoding device has columns of translator elements representing uncoded numbers; these elements selected by decoding bars which normally obstruct their movement. Patents 2,675,176 and 2,675,177 by John Perrin, assigned to Powers-Samas Accounting Machines Ltd., England.

• • •

Handling

ARTICLE FEEDING APPARATUS FOR AUTOMATIC MACHINES

Loading manifold with horizontally spaced pockets on a circle concentric with the manifold center —a circular transfer member within the manifold with recesses in its periphery that come tangent to the circle of spaced pockets such that the pockets are in turn loaded and unloaded as the device rotates. Patent 2,675,117 by Edwin C. Pinsenschaum, assigned to Denison Engineering Co.

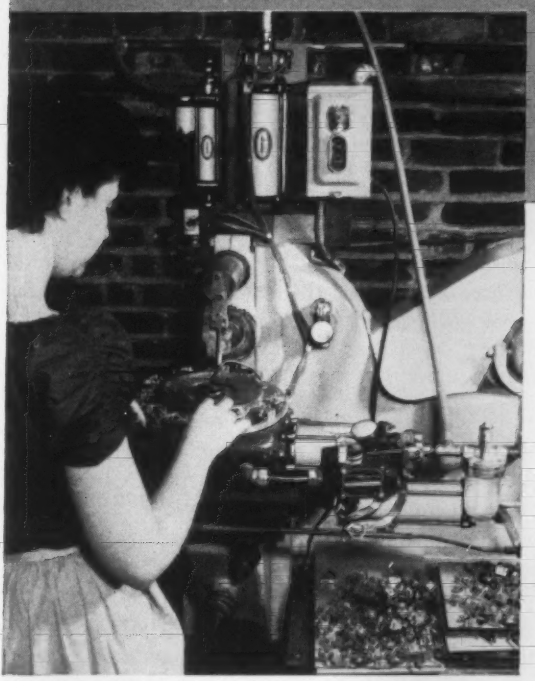
REEL FOR FEEDING COIL STOCK

Tension sensitive arm actuates switch means controlling energization and deenergization of electromagnetic clutch connecting motor and reel shaft. Patent 2,675,190 by Chester M. Wiig, assigned to F. J. Littell Machine Co.

OVERHEAD CRANE TROLLEY TURNTABLE

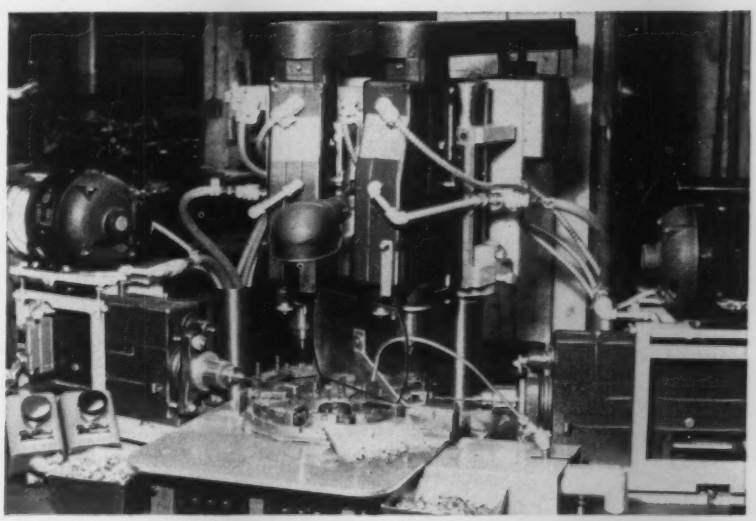
Hoist drums mounted on body are each driven by independently operated motors that straddle the drums and mount to the body in such a way as to be removable to facilitate servicing the drums. Patent 2,675,131 by Boris M. Osojnak, assigned to Heyl and Patterson Inc.

WITH THIS UNIQUE AIR MOTOR

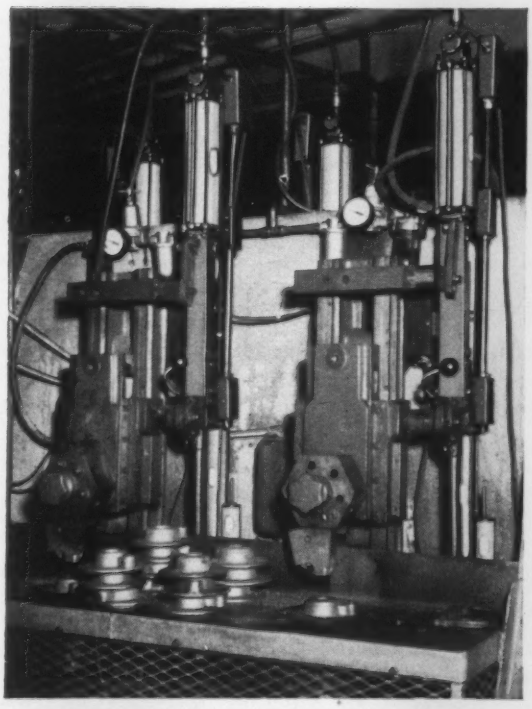


you can build cost-cutting special machines or modernize existing machines right in your own shop with your own personnel

This semi-automatic set-up at Eastman Manufacturing Co. doubled production and eliminated fatigue in milling bakelite magneto parts.



This drilling machine, built by Horrocks-Ibbotson, turned out 1 year's production of their fishing reel pawl blocks in 3 months.



A simple installation cut lathe time on steel ordnance parts from 90 to 10 seconds per piece at Joseph Pickard's Sons of Philadelphia.

Even for short runs you'll find special machines built around this versatile power unit will pay off in a big way — in greatly lowered costs, in fewer rejects, in better product quality. No expensive engineering is needed. In fact, your local Bellows Field Engineer may have in his Foto-Facts File basic designs that can be readily adapted to your product and your production processes.

Your own tool room can build such special machines at decidedly low cost, and quickly. Often they pay for themselves with the first week's savings.

The Bellows Co.

IN CANADA: Bellows Pneumatic Devices of Canada, Ltd.
4972 Dundas St., W., Toronto, Ontario

Bulletin CL-50 tells the story of the Bellows Air Motor and the part it is playing in cutting manufacturing costs in hundreds of plants Address. The Bellows Co., Dept. AU-1154, Akron 9, Ohio.

917-A

LATCH TRIPPING MECHANISM

Station on the trackway of a conveying mechanism that has a looped tripping arm yieldably mounted on a pivot. Device opens latch on bottom of drop door dumping conveyance. Patent 2,675,135 by Alfred F. Sanford II, assigned to the Sanford Investment Co.

SELF-ACTUATING RETURN CONVEYOR SYSTEM

Inclined belt conveyor delivers article to normally inoperative pivoted conveyor above. Load tips pivoted conveyor into operating position and load is delivered to return conveyor that is above inclined belt conveyor. Patent 2,675,118 by William E. Morrison, assigned to Armstrong Cork Co.

ARTICLE FEEDING DEVICE

Feeding tube is reciprocated vertically through apex of hopper cone thus maintaining top full of articles. Chuck at lower end of tube releases one part at lower end of down stroke and grasps next adjacent article at beginning of tube's upward movement. Patent 2,675,647 by Henry W. Roeber, assigned to Sylvania Electric Products Co.

♦ ♦ ♦

Machines

APPARATUS FOR COATING INCANDESCENT LAMPS WITH A DIFFUSING COATING

Disposable container within lamp envelope heats sublimed finely divided silica as diffusing medium. Photoelectric arrangement automatically shuts off heat when desired coating density is obtained. Patent 2,674,973 by Luke Thorington, assigned to Westinghouse Electric Corp.

DEVICE FOR FEEDING AND COATING FLAT ARTICLES

Cards with terminals, end portions of which project beyond the card, are supported while a pair of jaws with oil impregnated pads wipe oil onto the ends of the terminals. Patent 2,674,976 by Charles J. Roach, assigned to Western Electric Co.

APPARATUS FOR WINDING CONDENSERS

Support means and guide rolls for a pair of metallized tissue strip supply rolls and mechanism for winding both on work arbor and cutting off device for end of windup. Patent 2,675,188 by Leonard O. Larsen, assigned to Western Electric Co.

AUTOMATIC MOLDING MACHINE

Material fed through mold block to cavity by piston and cylinder action. Moveable mold block has knockout pins that remove parts from mold. Machine is equipped with ejector means that moves into space between movable block and knocked out part to free part from knockout pins. Patent 2,675,583 by George A. Scherry assigned to Grayhill.

PEACH AND APRICOT PITTING MACHINE

Conveyor apparatus with sets of wires that pass along both sides of the fruit seed and sever the flesh therefrom. Uses fruit carrying elements with side members cut out for receiving fruit seed and an inclined surface for guiding ejected seeds. Patent 2,675,039 by Frank W. Bauer.

MOLD FEEDING APPARATUS

Feed member periodically moved forward into register with mold cavity and returned to register with supply means. Equipped with adjustable adapter means to vary the capacity of the plastics powder measuring compartment. Patent 2,675,584 by Norman Fienberg and Alan Reginald Calder, assigned to A. C. I. Plastics Proprietary Ltd., Australia.

♦ ♦ ♦

Machine Tools

AUTOMATIC COPYING MILLING AND GRINDING MACHINE

Parallel arranged pattern and work blank mounts each supported on two mutually perpendicular pivots such as to wobble about the junction of these axes. Mechanism to transmit all wobble movements of the pattern mount to the work mount and maintain their parallel relationship. Tool spindle and feeler spindle are mounted parallel above the work and pattern and carry geometrically identical members linked to maintain constant relation. Patent 2,675,652 by Ruggero Chiappulini, assigned to Aktiengesellschaft Brown, Boveri and Cie., Switzerland.

♦ ♦ ♦

Measuring

NONCONTACTING WIDTH GAGE

Electron-optic electric signal generator produces one series of pulses for position of each edge of strip material. Electric signal intergrating means intergrates the two series of pulses and gives output indication of strip width. Patent 2,674,917 by Harry R. Summerhayes, Jr., assigned to General Electric Co.

TEMPERATURE MEASURING APPARATUS

Heater in constant heat loss chamber actuated by controller connected to first junction of one thermocouple. Second thermocouple has one junction for reference to constant temperature—the other junction is a sensing element exposed to temperature being measured. Patent 2,674,883 by Waldo H. Kliever, assigned to Minneapolis-Honeywell Regulator Co.

NONCONTACTING WIDTH GAGE

Electron cameras arranged for vertical scanning of opposite edges of object present electric signal, related to position of edge, to mixing circuit which

provides a composite electric signal related to total width of object. Patent 2,674,915 by Roy E. Anderson, assigned to General Electric Co.

• • •

Packaging

SPOT PASTING MACHINE

Oscillating ejection means puts portions of an adhesive on web of material moving along a path. Patent 2,674,978 by Clinton R. Hollis, assigned to Chemical Packaging Corp.

OLIVE PACKING MACHINE

Unit individually places articles such as olives and the like in predetermined relation within an open-topped container. Article receiving and retaining element is provided with horizontal and vertical movements in controlled path of cycle. Container-receiving structure rotates through predetermined arc and lowers elevation after each layer has been packed. Patent 2,675,153 by Gerald A. Weimer, assigned to Ernst and Ernst.

WRAPPING AND PACKAGING MACHINE

Feeds webs of wrapping material above and below a horizontal plane of movement of articles to be wrapped—cuts, overlaps and heat seals the edges. Patent 2,673,430 by Leo S. Fleischer and Richard C. Tackenberg, assigned to The Crystal Tissue Co.

CONTAINER CLOSING MACHINE WITH CENTERING DEVICE

Fingers centralize tubular container on lifter pad. End member attached in raised position of lifter—feeding means to remove containers. Patent 2,672,-791 by Howard B. Peterson and Edward DeGear, assigned to American Can Co.

• • •

Tooling

DIE MECHANISM

Female die sections in superimposed stack formation for trimming helical peripheral sections from previously formed blanks. Patent 2,674,924 by Moritz H. Nielsen, assigned to Illinois Tool Works.

• • •

Warehousing

AUTOMATIC MASTER LOAD WAREHOUSING

Transfer bridge platform suspended from an overhead bridge crane by telescopic multicylinder hydraulic means controlling the spacing between platform and bridge. System remotely controlled by solenoid actuated hydraulically operated valve. Patent 2,675,134 by Dean B. Becker.

FREE to Design, Plant, and Safety Engineers

A NEW, COMPLETE REFERENCE FILE OF BARKSDALE HYDRAULIC and PNEUMATIC CONTROLS

It includes important general information such as a detailed description and illustration of the Shear-Seal principle, the only new valving principle in centuries; covers manual and solenoid valves.

It contains a simplified chart for pressure switch selection, which sheds new light on a subject shrouded in mystery.

It presents the only line of solenoid-pilot valves for air and low pressure liquid with a guarantee for longer solenoid and valve life.

Down to the handy pop-up tab, nothing has been overlooked in providing a more useful reference to the design engineer concerned with hydraulic components.

Use the coupon below to get your *free* copy of this valuable information, indispensible to modern hydraulic control.

BARKSDALE VALVES

5125 ALCOA AVE., LOS ANGELES 58, CALIF.

Please send a copy of the above described *Free* catalog 4G.

NAME _____ TITLE _____

COMPANY _____

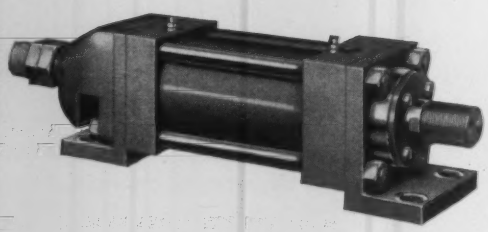
ADDRESS _____

CITY _____ ZONE _____ STATE _____

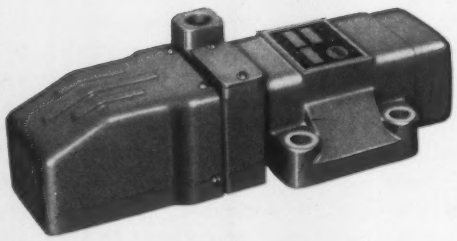
AUTOMATION

Realistic Planning

CALLS FOR PRACTICAL EXPERIENCE

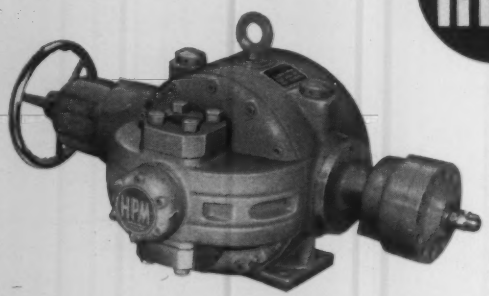


AIR AND OIL
HYDRAULIC CYLINDERS

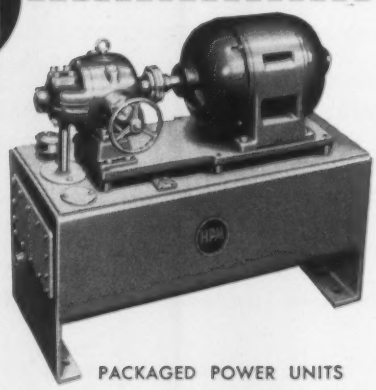


AUTOMATICALLY
CONTROLLED VALVES

HPM

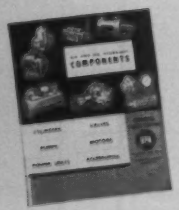


VARIABLE VOLUME
HYDRAULIC PUMPS



PACKAGED POWER UNITS

For over three-quarters of a century H-P-M engineers have designed equipment — and motions — for varied requirements. Now, with a complete line of air and hydraulic components as part of our standard line you are assured of complete responsibility for your automatic systems. The hydraulic cylinders, valves, pumps and power units illustrated are typical of the air and oil hydraulic equipment in the H-P-M line. Call in the H-P-M Field Engineer in your locality when power, or the control of power, is your problem. The experience of the H-P-M organization will be of real assistance.



This 28-page condensed catalog covers the complete H-P-M line of hydraulic components. Write for your copy.

DEPT.-B

HPM

HYDRAULIC
POWER
DIVISION
THE HYDRAULIC PRESS MFG. CO.
MOUNT GILEAD, OHIO, U. S. A.

new catalogs..... latest literature

Let us get them for you

Here is the latest in automation "how-to"—yours for the asking.

New Tube for Flow Metering

Builders-Providence, Inc.—Dall flow tube, a new, short differential producing, metering device is subject of a 16-page engineering bulletin. Flow tube is said to have the lowest permanent loss of head of any known velocity-increasing differential producer. Information includes recovery characteristics, accuracy, applications, range, flow formula, laying length, and working pressure. Sections discuss installation, power consumption, effect of approach and downstream piping and fittings, and location of instruments. Tables and graphs are included to aid in selection of the proper flow tube and secondary instruments.

Circle No. 60 on Reply Card

Contract Tooling for Industry

Mechaneers Inc.—Booklet is available on company's package tooling program for industrial clients. Case histories cited include an electric switch company requiring a fast automatic testing machine but with inadequate tooling and development facilities of their own. Service company's program starts with consultation on product blueprint and carries through to actual production without exceeding predetermined cost or delivery date.

Circle No. 61 on Reply Card

Hydraulic and Air Cylinders

Hanna Engineering Works — New line of fluid power cylinders features large capacity to size ratio, corrosion resistance, minimum friction, interchangeable components, positive cushioning, air operation up to 250 psi, and hydraulic operation up to 750 psi. Capacity charts, mounting installations, dimensions, and accessories are set forth in a 14-page catalog, as well as a check list of considerations to be taken in cylinder application and ordering specifications.

Circle No. 62 on Reply Card

DC Indicating Amplifier

Doelcam Corp.—Data sheet gives engineering data, performance curves, and typical applications of a new dc indicating amplifier. Unit is designed primarily as a polarity-sensing microvoltmeter for direct measurement of low level dc signals, for amplification to provide flat response to greater than 20 cycles per second to drive commercial pen motor or galvanometer recorders.

Circle No. 63 on Reply Card

General Purpose 2-Way Valve

Automatic Switch Co.—Pertinent data on 2-way, internal pilot operated, solenoid valves is set forth in a 4-page bulletin. Valves control flow of air, gas, water, light oil, and other noncorrosive fluids, and can be applied to instrumentation, machine tools, and appliances. Dimensional diagrams, flow charts, and list prices included.

Circle No. 64 on Reply Card

Oxygen-Free Atmosphere

Arnold O. Beckman, Inc.—Accurate instrumentation and process regulation provide inert, oxygen-free gases to heat treating, welding, sintering and coating of metals. Bulletin listing and describing necessary equipment is titled "Atmosphere Furnaces".

Circle No. 65 on Reply Card

Variable Speed Drive and Control

U. S. Electrical Motors Inc.—An automatic drive and control for use in operations involving variables such as temperature, pressure, speed, liquid level, weight, tension, and position are known as Varidrive and Varitrol. Four-page bulletin gives operating data and applications which include program and machine tooling control. Varitrol is basically a pneumatic amplifier composed of a power and a signal system. High pressure power system operates piston in the cylinder, is controlled by a low pressure signal system. Drives are available from ⅛ to 30 hp with speeds from 14 to 14,000 rpm.

Circle No. 66 on Reply Card

Synchronous Motor-Alternator

Electric Motors and Specialties, Inc. Motor-alternator can be applied to laboratory test equipment, servos, electronic controls, indicating systems or any other device requiring a source of single or three-phase, 420 c.p.s. current. This Model SA-40 has two-bearing construction, single shaft for motor and alternator and weighs 60 lbs. Data sheet includes standard dimensions and typical performance data.

Circle No. 67 on Reply Card

Dynamic Pressure Measurement

Statham Laboratories, Inc.—The 27th issue of *Instrument Notes*, a series of design data summaries in the physical measurement field, is available to those interested in evaluating the design of transducers for the measurement of dynamic pressures in liquid systems. Eight-page study points out principal factors influencing the selection of unbonded strain wire transducers for measuring dynamic pressures in liquid systems, and presents calculated and experimental data demonstrating effect of varying some of the design parameters of pressure transducers. Author evolves a simple method for predicting the natural frequency and damping ratio of a liquid-filled tube plus transducer system by means of a small-bore, graduated glass capillary tube and a source of known pressures.

Circle No. 68 on Reply Card

Automatic Shovel

Hamilton Automation, Inc. Illustrations and specifications of automatic shovel are included in this bulletin sheet. Shovel is air operated, removes parts from punch press dies automatically and is a self-contained unit.

Circle No. 69 on Reply Card

Plug Valve Actuators

Ledeen Mfg. Co.—Tandem type actuators for valves requiring high torques for operation, and new floating bar type actuators for valves requiring lower operating torques are subjects of an 8-page bulletin. Actuators are pneumatically or hydraulically operated for remote control and automatic processing applications, can be installed on new valves or existing valves already in service. In addition to an actuator selection table, bulletin gives typical applications, dimensions and weights, and illustrates various mountings and accessories.

Circle No. 70 on Reply Card

Magnetic Particle Clutches, Brakes

Vickers Electric Div., Sperry Corp.—Four-page bulletin describes "Magneclutch" and "Magnebrake" line which operates on a magnetic particle principle. Clutch transmits torque through the magnetic medium to provide smooth acceleration, may be operated manually, by adjustable resistor, potentiometer, or automatic control. Gears, sprockets, linings, pressures, and other mechanical clutching devices are eliminated. Magnebrake provides preset or adjustable braking, from full speed to standstill, without grab or friction wear. Suggested applications include conveyors, dynamometers, automatic lathes, pumps, separators, and vibrators.

Circle No. 71 on Reply Card

Controlled Volume Pumps

Milton Roy Co. Twenty-page bulletin describes use of controlled volume pumps as flow controllers, ratio controllers and final control elements in process instrumentation. Types, operation and applications of pumps in chemical, petroleum, paper, food, water treating and other industries are included, along with engineering data.

Circle No. 72 on Reply Card

Tests for Lubricating Oils

Crippin & Erlich Labs, Inc. This four-page bulletin lists test for fuels, coal, tars, asphalts, petroleum and oils which are used to lubricate and power automatic equipment. More than 60 tests are included in the bulletin.

Circle No. 73 on Reply Card

Highlights in PEC Progress

Patterson, Emerson, Comstock, Inc. Pictures and descriptions of company products and achievements comprise this 44-page bulletin. PEC electrical construction installations in boiler houses, switchyards, substations, arc furnaces and strip m'''; in operation are among illustrations. A list of PEC's principal clients is also included.

Circle No. 74 on Reply Card

new catalogs..... latest literature

Let us get them for you

Plastic Heat Sealing for Packaging

Vertrod Corp.—Heat sealers which weld thermoplastic films, heated by short, powerful heat impulse and then cooled under pressure, are subject of illustrated 4-page bulletin. Machine consists of two metal bars which act as jaws. Pressure bar has soft rubber surface, while heater bar consists of an insulated resistance wire. Jaws close over film, current impulse is applied, weld cools under pressure and develops full strength. Heat sealing may be used on manual or foot operated sealers, on power-driven bag sealing and bag making machines, and fully automatic packaging equipment. Various models and prices listed.

Circle No. 75 on Reply Card

Tools of Automation

Reliance Electric & Engineering Co. Automation of single machines or continuous processes is discussed in this 12-page bulletin. Separate sections are devoted to precision built motors, V-S drives, controls and regulators with pictures and data covering each. Final section includes captioned photographs which illustrate automation at work in many industries.

Circle No. 76 on Reply Card

Power Spray Washers

Peters-Dalton Inc. — Spray washers, designed for use in metal-working industry are the subject of this 15-page bulletin. Washers can be used on television tubes, heavy machined parts, rotary shells, meat hooks, helical drums and numerous other types of equipment. Layouts and applications, along with 15 engineering drawings of most commonly used washers are included.

Circle No. 77 on Reply Card

Rotary Tables for Indexing, Milling

W. B. Knight Machinery Co.—Power feed rotary tables suitable for rotary milling and indexing, automatic cycle milling and indexing, and continuous face milling have infinitely variable feed drive controlled by limit switches. Eight-page bulletin illustrates and describes the two models, a 20-in. table and a 42-in. version which can be increased to 72-in. diameter with the use of subplates. Sectional views, diagrams, and specifications included.

Circle No. 78 on Reply Card

Power and Speed Control Combination

Dynamatic Div., Eaton Mfg. Co.—Fractional horsepower Adjusto-Spede drives are a combination of ac constant speed induction motors, eddy current couplings, and electronic speed control. Units, engineered to meet specific needs of fractional horsepower drives, are said to have wide speed range, accurate control, low power loss, simple and self-contained construction, and rapid response. Eight-page bulletin covers fundamentals of operation, capacity of available units, mechanical construction features, and control.

Circle No. 79 on Reply Card

Potentiometer Handbook

Technology Instrument Corp. This comprehensive 234-page loose-leaf publication proves an informative guide for the users of precision potentiometers. Divided into two sections, handbook and catalog, it gives thorough coverage to the basic elements of a precision potentiometer, its terminology, characteristics, and applications. The catalog section includes a complete description of the TIC precision potentiometer line and the entire book is supplemented with sketches, charts and specifications sheets.

Circle No. 80 on Reply Card

Automated Machine Tools

Turchan Follower Machine Co.—Three automation systems offered by company are (1) automatic control systems for machine tools already in use, (2) entirely new servo controlled machine tools, and (3) servo control systems built into products of major machine tool manufacturers at their plant. Well illustrated and diagrammed 24-page booklet discusses principles of automation, shows typical control applications, and features two specialized tracer-controlled machines now in production—the hydro-router for production routing and milling, and the vertical contouring lathe for reproducing irregular contours.

Circle No. 81 on Reply Card

Infrared Process Stream Analysis

Perkin-Elmer Corp. — An infrared process stream analyzer can be used in the plant or field for most gas and some liquid analyses which lend themselves to solution by laboratory infrared spectrometers. Analyzer is basically an automatic recording, triple-beam, non dispersion plant instrument utilizing a servo driven attenuator comb in the third beam to produce a true radiation null at the detector. Six-page illustrated bulletin describes operation, specifications, and typical applications.

Circle No. 82 on Reply Card

Adjustable Relays

A. W. Haydon Co. New line of hermetically-sealed adjustable time delay relays for military operations under severe environmental conditions is discussed in a two-page catalog sheet. Details on housings, settings, motors, operations, calibration, and hermetic sealing are included. Diagrams and chart give specifications of relays.

Circle No. 83 on Reply Card

Screwdriving Machines and Equipment

Detroit Power Screwdriver Co. Thoroughly-illustrated, 40-page bulletin discusses complete line of screwdriver machines, fixtures, hopper units, nut drivers, and special assembly machines. Specifications, descriptions, applications, photographs and dimensional layouts of various models are included in this comprehensive bulletin.

Circle No. 84 on Reply Card

Design of Saturating Servomechanisms

Cook Electric Co.—A 16-page booklet entitled, "Design Considerations of a Saturating Servomechanism" takes general principles underlying multiple mode control of servomechanisms and determines optimum values with which the designer can synthesize a saturating linear servo system that will have a response approaching that of the optimum-ly switched servo. Relationship between saturated and unsaturated regions is shown, and method whereby the effects of torque and velocity saturation can be considered when choosing the linear parameters. Effects of various damping factors upon the saturating response are described by phase plane analysis. Phase plane allows determination of optimum response of system for a given motor and load.

Circle No. 85 on Reply Card

Record Playback Control

General Electric Co.—Illustrated 6-page bulletin describes system of recording motion on magnetic tape and playing it back for automatic programming of production machines. Recording is taken by selsyns (synchros) coupled to feed motors to report motors' angular positions to tape by electrical signals. Recording can be taken of operator's manual operation of machine, or, for more complex parts, of motion of a tracer head. Still in planning stages are recording systems taken from line drawings requiring no machine setup, and operation from digital information which will be punched on paper tape.

Circle No. 86 on Reply Card

Loadmeter

Detroit Milling Cutter Co. Described as the "arch enemy of tool breakage, machine breakdown and work spoilage", loadmeter is mounted on any type of motor driven equipment, indicates trouble, then instantly shuts off motor, feed, or whatever is necessary in individual case. Models L100 and L122 are furnished with 8' leads. Four-page, two-color brochure contains pictures, descriptions, installation instructions, and prices of three models.

Circle No. 87 on Reply Card

Precision Cams

Ford Instrument Co. Three dimensional cams, with tolerances to ± 0.0005-in. and single input cams with tolerances to ± 0.0001-in. are described in this four-page bulletin. "Three-D" cams can be used for jet fuel supply as a function of rpm and temperature; AA ballistic corrections as a function of elevation angle and range or time of flight; bomb characteristics as a function of air speed and altitude or dive angle; and magnetic variation as a function of latitude and longitude. Functions cut into single input cams are: squares, roots, reciprocals, trigonometric functions, logs, reciprocals of square roots, combined trigonometric functions, and empirical functions such as ballistic data. Bulletin is two-color; contains four pages.

Circle No. 88 on Reply Card

save time

OPEN FLAT and circle numbers on reply card as you read this issue

Conveyor Rolls

Boxley Co. "Z" design conveyor rolls, used for moving raw materials to machines and parts in process between operations, are the subject of a four-page illustrated brochure. Rollers continuously conform to varying contours of moving load, and are supplied in either soft or medium grade oil-resistant synthetic rubber, with ¼-in. socket head cap screws, tube-type spacers, and self-locking jam nuts.

Circle No. 89 on Reply Card

Miniature Actuator Motor

Dalmotor Co.—Engineering data, dimensional drawing, performance graph, and electrical and physical characteristics for an actuator motor are set forth in a data sheet. This motor is a series-wound, 25 w, miniaturized unit, and is capable of 20,000 rpm. It is designed primarily as a driving element in low or high speed linear or rotary actuator applications.

Circle No. 90 on Reply Card

Hydraulic-Pneumatic Testing Panels

Industrial Engineering Corp.—A line of test stands and panels for analysis of hydraulic-pneumatic flow rates, timing, calibration, and leak detection in valves, servos, motors, etc., features built-on flow diagrams so that operating instructions are in full view. Stands handle fluid testing at static pressures up to 50,000 psig or flow rates up to 150 gpm. Six-page bulletin offers complete description plus information on company's gage guard, a protective pressure cutoff control.

Circle No. 91 on Reply Card

Electrical Contact Rivet Slide Chart

Fansteel Metallurgical Corp.—A copyrighted slide chart is available to facilitate selection of solid or composite rivet type electrical contacts. Maximum and minimum dimensions for head thickness, shank diameter, and shank length for a given rivet head diameter can be determined for rapid and economic production of contact rivets on automatic heading machines.

Circle No. 92 on Reply Card

Automatic Spray for Die Press

Hamilton Automation Inc.—Die presses can be equipped with an automatic spray unit which will spray compound automatically at each press stroke in metered amounts to critical locations. Press need not be stopped to spread compound on lower part of the die, compound is not wasted, and die life is increased. Folder is available describing unit and components.

Circle No. 93 on Reply Card

INDEX OF PRODUCTS BY ITEM NUMBERS

(New Equipment, New Components, and New Literature covered in this issue)

Actuator 70, 90
Aircraft computer 98
Alarm, temperature ... 2
Ammeter 35
Amplifier 63
Assembly 7, 14, 84

Brake 46, 71
Broaching machine ... 95

Cams 88
Chemical service motor. 43
Chucks, magnetic 101
Circuit interrupter 49
Cleaning..4, 18, 77, 114, 129
Clutch, magnetic 71
Computer, aircraft 96
Computer, analog 102
Connector, electrical ..
..... 28, 33, 38
Contact, electrical 92
Contract engineering ..
....61, 74, 100, 128, 130
Contract testing 73
Control
electrical 87
electronic 20
instrument...60, 98, 112
motor 20
pneumatic 116
program 50
record playback 86
speed .....
..20, 48, 66, 76, 79, 110
timer 49, 127
Converter, analog-digital 57
Conveyors
belt 47
overhead rail 8
roller 89
systems 4, 94
Cutting tool 119
Cylinders
general 108
hydraulic 62
pneumatic 27, 51, 62

Data handling 57, 99
Diodes, germanium 56
Drilling machine 16
Drive
adjustable speed 79
mechanical 22
variable speed....66, 110
Dumper, tote pan 21

Electric components ...
.....26, 28, 29, 33, 34, 37, 38, 40, 49, 54, 55, 56, 80, 83, 103, 111, 124, 125
Electrical construction.. 74
Electrical control 87
Electronic control 20
Engineering, contract ..
....61, 74, 100, 128, 130

Filling machine ...10, 104
Filters, hydraulic 23
Finishing
attachments 8
machines 24, 114
Fittings 59
Flare connector 59
Flow
pump 72
regulator 30
tube 60

Gage, vacuum 41
Gas valve 31
Gases 65
Generator, electric ....
..... 52, 58, 67

Handling
conveying .....
....4, 8, 47, 89, 94, 109
dumping 21
feeding 21
general 13
indexing 15, 78, 126
loading 6
remote 19
unloading 6, 69
weighing 5, 12
Heat treating...25, 47, 65
Hydraulic
components .....
30, 34, 55, 70, 97, 120
cylinder 62, 108
power unit 32
testing 91
vise 45

Indexing tables. 15, 78, 126
Indicator, temperature. 2
Instrument control ....
.....50, 98, 102, 112
Instruments
panel .....
..2, 36, 39, 41, 91, 106
pressure 53, 68, 105
recording 36, 44
testing....35, 42, 82, 106

Loader 6
Loadmeter 87
Lubricant, test 73

Machine accessories ...115
Machines
casting 17
molding 17
screwdriving 84
tube filling 10
wire joining 7
Machine tools
cold-forming 122
drilling 16
general 81, 95, 123
welding 1
Machine tool attachments..11, 16, 45, 87, 93
Magnetic brake 46
Manipulator 19
Meter 42
Microammeter 35
Milling machine 95
Molder, caster 17
Motors
ac 76
actuator 90
alternator 67
controller 20
general 43

Package sealing 75
Packaging machine ...
.....9, 10, 12, 104
Panel instruments .....
....2, 36, 39, 41, 91, 106
Parts cleaning .....
.....4, 18, 77, 114, 129
Parts manufacturing transmission housings 3
Plants, automating ...
.....76, 100, 117
Pneumatic
clamps 27, 121
control 116
cylinder 27, 51, 62
feed 16
power unit 32
testing 91
vise 45
Positioning table 11
Potentiometers.29, 80, 103
Power supply 32
Press, spray for 93
Pressure
measurement 68, 105
switch 34, 55
transmitter 53
Program controller ... 50
Pumps, flow control ... 72
Punched card data handling 99

Record playback control 86
Recorder
graph 36, 44
remote 105
Reducer, speed 48
Regulator, flow 30
Relays, electric .....
..26, 37, 54, 83, 111, 125
Resistors, capsulated... 40

Screwdriving machine.. 84
Sealing, heat 75
Servomechanisms 85
Sheet metal handling...
..... 13, 109
Shovel 69
Spectrometer 82
Speed reducer 48
Switches
pressure 34, 55
stepping 26

Tachometer 52, 58
Telemetering 36, 105
Temperature indicator.. 2
Test stands 91, 106
Testing, contract 73
Testing controller 50
Timers 49, 127
Tooling 61, 95
Tools 119, 121
Tracer, machine tool... 81
Transfer machines
general 14, 22, 123
transmission housings 3
Transformer 39
Transistor 107
Transmission 113
Transmitter, pressure.. 53
Tube filler 10
Tube fittings 59
Typewriter, automatic..124

Unloader 6
Unloading 69

Vacuum gage 41
Valves
actuator 70
gas 31
general 118
solenoid 31, 64, 118
Vise 45
Voltmeter 42

Weighing 5, 12, 112
Welding machine 1
Wire joiner 7
Wrapping, taping machine 9

Use A Reply Card—No Postage Required

NAME _____ TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY & STATE _____

Must Be Filled Out Completely—Type or Print

NOVEMBER 1954

NEW LITERATURE OR INFORMATION ON NEW EQUIPMENT AND COMPONENTS (Circle Item Numbers)

1	2	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17	18	19	20	21	22	23	24	25	26
27	28	29	30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49	50	51	52
53	54	55	56	57	58	59	60	61	62	63	64	65
66	67	68	69	70	71	72	73	74	75	76	77	78
79	80	81	82	83	84	85	86	87	88	89	90	91
92	93	94	95	96	97	98	99	100	101	102	103	104
105	106	107	108	109	110	111	112	113	114	115	116	117
118	119	120	121	122	123	124	125	126	127	128	129	130
131	132	133	134	135	136	137	138	139	130	141	142	143

FOR EDITORIAL CLIPSHEETS (Circle page number below)

Article starting on page—							
17	22	28	39	46	49	61
18	23	31	44	47	59	

MORE INFORMATION ON ADVERTISED PRODUCTS

Circle page number. Key: IFC—Inside front cover, IBC—Inside back cover, OBC—Outside back cover, L—left, R—right, T—top, B—bottom.

IFC	7	65	76	84-5	93	109	117TR
1	11	66	77	87	95	111BL	IBC
2	13	71	79	89	96	111BR	BC
5	15	73	81	90TL	105	113TL	
6	16	75	83	91	107	113TR	

FIRST CLASS
Permit No. 36
(Sec. 34.9 P.L.&R.)
CLEVELAND, OHIO

BUSINESS REPLY CARD

No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

AUTOMATION

Penton Building

Cleveland 13, Ohio

Readers Service Dept.

NAME _____ TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY & STATE _____

Must Be Filled Out Completely—Type or Print

NOVEMBER 1954

NEW LITERATURE OR INFORMATION ON NEW EQUIPMENT AND COMPONENTS (Circle Item Numbers)

1	2	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17	18	19	20	21	22	23	24	25	26
27	28	29	30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49	50	51	52
53	54	55	56	57	58	59	60	61	62	63	64	65
66	67	68	69	70	71	72	73	74	75	76	77	78
79	80	81	82	83	84	85	86	87	88	89	90	91
92	93	94	95	96	97	98	99	100	101	102	103	104
105	106	107	108	109	110	111	112	113	114	115	116	117
118	119	120	121	122	123	124	125	126	127	128	129	130
131	132	133	134	135	136	137	138	139	130	141	142	143

FOR EDITORIAL CLIPSHEETS (Circle page number below)

Article starting on page—							
17	22	28	39	46	49	61
18	23	31	44	47	59	

MORE INFORMATION ON ADVERTISED PRODUCTS

Circle page number. Key: IFC—Inside front cover, IBC—Inside back cover, OBC—Outside back cover, L—left, R—right, T—top, B—bottom.

IFC	7	65	76	84-5	93	109	117TR
1	11	66	77	87	95	111BL	IBC
2	13	71	79	89	96	111BR	BC
5	15	73	81	90TL	105	113TL	
6	16	75	83	91	107	113TR	

FIRST CLASS
Permit No. 36
(Sec. 34.9 P.L.&R.)
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed in the United States

—POSTAGE WILL BE PAID BY—

AUTOMATION
Penton Building
Cleveland 13, Ohio

Readers Service Dept.

NAME
TITLE
COMPANY
PRODUCT MANUFACTURED
ADDRESS
CITY & STATE

Must Be Filled Out Completely—Type or Print

NOVEMBER 1954

NEW LITERATURE OR INFORMATION ON NEW EQUIPMENT AND COMPONENTS (Circle Item Numbers)

1	2	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17	18	19	20	21	22	23	24	25	26
27	28	29	30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49	50	51	52
53	54	55	56	57	58	59	60	61	62	63	64	65
66	67	68	69	70	71	72	73	74	75	76	77	78
79	80	81	82	83	84	85	86	87	88	89	90	91
92	93	94	95	96	97	98	99	100	101	102	103	104
105	106	107	108	109	110	111	112	113	114	115	116	117
118	119	120	121	122	123	124	125	126	127	128	129	130
131	132	133	134	135	136	137	138	139	130	141	142	143

FOR EDITORIAL CLIPSHEETS (Circle page number below)

Article starting on page—17 22 28 39 46 49 61
18 23 31 44 47 59

MORE INFORMATION ON ADVERTISED PRODUCTS

Circle page number. Key: IFC—Inside front cover, IBC—Inside back cover, OBC—Outside back cover, L—left, R—right, T—top, B—bottom.

IFC	7	65	76	84-5	93	109	117TR
1	11	66	77	87	95	111BL	IBC
2	13	71	79	89	96	111BR	BC
5	15	73	81	90TL	105	113TL	
6	16	75	83	91	107	113TR	

FIRST CLASS
Permit No. 36
(Sec. 34.9 P.L.&R.)
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed in the United States

—POSTAGE WILL BE PAID BY—

AUTOMATION
Penton Building
Cleveland 13, Ohio

Readers Service Dept.

New Catalogs & Literature

Comprehensive Conveyor Parts Catalog

Link-Belt Co.—A new 340-page catalog has thumb index to provide easy and rapid selection of standard products. Major product classifications include chains and sprockets for conveying, elevating and power transmission; enclosed gear drives and variable speed drives; ball and roller bearings, babbitted bearings, pulleys, gears, clutches, and couplings for power transmission; components for screw, belt, oscillating, and bucket conveyors. Capacity charts and dimension tables aid in selection of products.

Circle No. 94 on Reply Card

Standard Tools and Machines

Zagar Tool, Inc. Zagar engineering equipment for drilling, milling, tapping and broaching is described in an eight-page brochure. Among standard and semi-standard equipment are: gearless drill heads, self-clamping drill jigs, feed units, heavy duty drilling machines, hydraulic broaching machines, special drilling machines, collets, holding and indexing fixtures, and lathe chucks. Bulletin gives pictures, general specifications and applications of equipment.

Circle No. 95 on Reply Card

Air Data Computer

Servomechanisms, Inc.—Assembly of plug-in components, with associated transducers, provides input information required by the computers and controls governing operation of an aircraft and its armament. Eight-page brochure describes how computer measures and converts to electrical signals fundamental input data which defines environment and operation of aircraft, and then uses signals through servos to produce functions of input parameters in the required form. Schematic diagrams are included.

Circle No. 96 on Reply Card

Hydraulic Components

Hydraulic Press Mfg. Co.—Nine separate catalogs are devoted to distinctly separate components in company's hydraulic line. Each catalog contains all basic data needed by engineer including photos, cross section views, dimensions, operating control diagrams. Subjects of individual catalogs are: pumps, motors, and power units; air and oil hydraulic cylinders (four catalogs); valves and flange connections; valves and gasket mountings; valves and threaded connections; and an engineering manual.

Circle No. 97 on Reply Card

Monitor and Control Instruments

Consolidated Engineering Corp.—Electronic instrumentation is applied to petroleum, chemical, and medical uses, pressurized and vacuum product testing, and continuous, automatic monitoring and control of gas or liquid flow lines for evaluation of products and processes. Catalog enumerates case histories for various industries with good illustrations in 22 pages, and includes descriptive data on company's control and test instruments.

Circle No. 98 on Reply Card

Data Handling by Punched Cards

Remington Rand Inc.—Multi-control reproducing punch uses punched card procedure for descriptions, analyses and breakdowns, extending and computing, searching and sorting, verifying, comparing, correcting, reproducing and interfiling data. Six-page bulletin illustrates procedure, which will handle 6000 to 12,000 cards per hour, and recommends it for production control, payroll and tax accounting, billing, and statistics preparation.

Circle No. 99 on Reply Card

Study of Automating Plants

T. A. B. Engineers, Inc.—An engineering firm has published a concise, 4-page booklet to aid executives in understanding the current significance of automation and in determining whether their factories can be adapted to it. "Cut Costs with Automation" discusses the history and evolution of automation, and contains a check list questionnaire to help evaluate reader's own company, plant and product to determine the practicability there of automation or partial automation.

Circle No. 100 on Reply Card

Magnetic Chucks and Devices

Hanchett Magna-Lock Corp. Eight-page bulletin describes entire line of chucks which offer larger magnetic surface, protection against moisture, maximum holding power, shock-proof construction, and electric control. Models include "supreme" for heavy machining, "swiveling" for knife and shear blade grinding, "rotary" for automatic loading and unloading and all-purpose "universal." Dimensions, pictures and an inserted price list complete the bulletin.

Circle No. 101 on Reply Card

Computer Analysis of Instruments

Beckman Instruments, Inc. — "Computer Techniques in the Instrumentation Industries" is a 5-page bulletin covering use of analog computer in design and control problems of instrumentation. An explanation of techniques involved in dynamic analysis of an instrument in use with its associated equipment shows simulation of process control systems and use of analog computer. Galvanometer and process control simulation and an analysis of a motor controller are demonstrated.

Circle No. 102 on Reply Card

Metallic Film Potentiometers

Potentiometer Div., Fairchild Camera & Instrument Corp.—"General Design and Performance Characteristics of Film Type Potentiometers," a paper presented at the 1954 Electronic Components Symposium, is available to all interested engineers. Outstanding features of a metallic film type resistance element in potentiometers include infinite resolution, high temperature operating capability, and a wide resistance range in small diameter units.

Circle No. 103 on Reply Card

Automatic Filling Machines

Peri Machine Manufacturing Co.—Four-page circular describes four different fully automatic Peri filling machines. Model "100" does straight line bottle and can filling; model "105" has output of 30 one-gallon cans per minute with eight valves. Features and pictures of machines are given.

Circle No. 104 on Reply Card

Telemetering Booklet

Bristol Co.—Almost 100 photographs illustrate applications of a line of Metameter telemeters to measurement and transmission of pressure, flow, liquid level, mechanical motion, electrical units and totalized power load in a 44-page booklet. Telemetering over telephone circuits, carrier current, and private wires is featured, as well as microwave, time multiplexing, and selective calling. Metagraphic recorders and indicators for use as metameter receivers on graphic panels and consoles are included.

Circle No. 105 on Reply Card

Standard Products

Industrial Engineering Corp. Bulletin covers three products in the instrument and test equipment field—test stands, test stand cabinets and instrument panels and gage gards. Test stands have electric, pneumatic or hydraulic schematic diagram of test unit shown in mimic symbols and colored tubing on instrument panel. Construction details for various designs of cabinets are described in the six-page bulletin, along with those of gage gards which are designed to protect against over-range of pressure measuring systems from 20-in. to 10,000 psig.

Circle No. 106 on Reply Card

Silicon Transistors

Texas Instruments Inc.—Descriptive data sheets present mechanical and electrical data, and operating conditions for a medium power and two general purpose silicon transistors. Silicon models are said to offer higher power output and be more independent of ambient temperatures than germanium counterparts. New transistors operate up to 150° C with current amplification essentially independent of temperature change.

Circle No. 107 on Reply Card

Cylinder Program

Miller Fluid Power Co. Well-illustrated, 12-page booklet describes standardization of critical cylinder mounting dimensions and stroke lengths, interchangeable mountings, complete line of bores, strokes and models for custom requirements and heavy duty cylinders—all built for automation. Comprehensive drawings and tables demonstrate large degree of standardization of critical mounting dimensions between various cylinder manufacturers, and internal fluid pressure stresses of essential cylinder components.

Circle No. 108 on Reply Card

Automated Sheet Metal Handling

Fried Steel Equipment Mfg. Corp.—A line of strip and materials handling devices for automating sheet metal plants and warehouses includes a Stripveyor to pick up and carry strips beyond shear bed as fast as they are sheared, a Strip-Stacker to stack and store the strip, a Liftveyor to support sheet being cut to tolerances as close as 0.005-in. and to counteract flexing. Eight-page bulletin illustrates and describes three basic machines fully, includes brief summary of an auxiliary scrap eliminator and beltveyor for short shearings.

Circle No. 109 on Reply Card

Keep Up to Date! Use a Postage-Paid Reply Card

Variable Speed Drive

Speed Control Div., Fairchild Engine & Airplane Corp. Attractive six-page bulletin describes Specon electrical differential drives, which maintain efficiency by keeping part of power flowing directly through the gears to the output shaft and maintain full-rated torque at all speeds including zero. Drive can be manufactured in any size required from fractional hp to several hundred hp. Bulletin contains dimensions, ratings and color pictures of various models.

Circle No. 110 on Reply Card

Relays

Magnecraft Electric Co.—Complete line of relays, including long and short form telephone type, sub-miniature, latching and low capacitance, and open, plug-in, hermetically sealed relays, is described with engineering and dimensional data in new catalog.

Circle No. 111 on Reply Card

Instrument Control for Hopper Scale

Richardson Scale Co.—A complete weighing, indicating and recording cycle is described in booklet on instrument system for use with hopper scales. System features interlocking switches, time delay before full balance printing, partial draft printing, follower dial accuracy, and dust control provisions. Dimensional engineering drawing and table listing headroom requirements for hopper scale included.

Circle No. 112 on Reply Card

Correction and Variable Transmissions

Machine-O-Matic, Inc. Single unit variable and correction transmissions are the subject of a four-page bulletin which includes sketches, charts and diagrams. Units permit splitting of single tooth on a change gear, and act as vernier adjustment when used with other variable transmissions. Corrections transmissions are designed to operate with electronic controls.

Circle No. 113 on Reply Card

Ransomatic

N. Ransohoff, Inc. Compact machine, the Ransomatic combines all necessary processes for efficient washing, pickling and neutralizing of metal parts automatically prior to plating. Machine has vertical centrifugal packless pumps to minimize problem of pumping, cleaning, and pickling solutions, adjustable trunnions, chip baskets which strain all liquids, and requires only one sewer connection. Four-page bulletin includes diagrams and photographs of machine.

Circle No. 114 on Reply Card

Parts for Production Machinery

A. & A. Mfg. Co.—Fourteen methods of fabricating pliable parts for automatic production equipment are illustrated in data sheet. These include dust covers, sleeves, boots, diaphragms, etc. Suggested materials are 0.033-in. for high speed flexing purposes, 0.050-in. for toughness or self-supporting rigidity, and solid neoprene block for shock absorption.

Circle No. 115 on Reply Card

Pneumatic Controllers

Fischer & Porter Co.—Stack type pneumatic controllers, for process variables such as flow rate, liquid level, viscosity, pressure, temperature, and vacuum, are illustrated with cutaway photographs, schematic diagrams, and dimensional drawings in a 12-page catalog. Specifications, controller selection guide, controller response actions, and accessories are included. Units can be case, field, or valve mounted.

Circle No. 116 on Reply Card

Automation In Industry

Associated Metal Fabricators, Jersey Sheet Metal Products, Inc.—A study of increasing production efficiency and lowering costs through automation demonstrates latest production line techniques by a selection of mechanized equipment. Booklet covers industrial racking equipment and special heavy duty metal working machines.

Circle No. 117 on Reply Card

Ledeen Valves

Ledeen Mfg. Co. Line of standard, 4-way hand, foot, power and solenoid operated valves is the subject of a 16-page bulletin. Also discussed is a new line of pilot valves. Dimensions and weights, application diagrams, circuit diagrams, parts list and accessories are covered.

Circle No. 118 on Reply Card

Standard Tools and Blanks

Firth Sterling, Inc. Comprehensive 36-page catalog gives grades, sizes, shapes, finishes, tolerances and price lists of Firthite standard blanks and tools. Among the blanks described are pointed and round nose tool tips; threading, masonry, scraper, reamer, lathe and grinder center tips; solid disc and gage bushings. General purpose tools, mechanigript and mechaniclampt toolholders, boring tools and bits and others are also included, along with sketches of each.

Circle No. 119 on Reply Card

Hydraulic Packing Protection

Hydraulic Accessories Co.—"Seal-Guards", metallic rod wipers, are installed on hydraulic packings to remove sand, grit, paint or chips before they reach internal hydraulic parts. Data sheet gives ordering information and installation instructions, as well as description and illustrations.

Circle No. 120 on Reply Card

Knu-Vise Products

Lapeer Manufacturing Co. Complete line of Knu-Vise products such as clamps, pliers and wrenches are outlined in this 26-page bulletin. Air-operated automatic clamps with toggle-bar forces up to a ton of pressure are covered. Clamps are designed for single installations, multiple installations controlled by a single valve, and multiple installations with sequence valve. Bulletin includes specifications, price list and pictures of models.

Circle No. 121 on Reply Card

Chipless Machining

Michigan Tool Co. New "chipless machining" process for cold-forming splines, serrations and similar forms is outlined in four-page illustrated bulletin. Background of this new metalworking technique, called "Roto-flow" is given, along with tooling, parts formed, automation of the cold-forming machines, typical applications and design advantages.

Circle No. 122 on Reply Card

Standard Automation Units

Wilson Automation Co. The concept of automation and some of its standards units manufactured by Wilson are the subject of this 17-page bulletin. Units such as control-section transfer, gate transfer, turnover, lengthwise transfer and turnaround are pictured. A typical automation plant layout, which is included in a Wilson project study booklet is also shown.

Circle No. 123 on Reply Card

Auto-Typist

American Automatic Typewriter Co. Pneumatically powered machine, which operates both manual and electric typewriters automatically is the subject of this 6-page bulletin. Auto-typist operates 2½ times faster than human fingers by means of recording precomposed letters or paragraphs on a roll. Operator can select appropriate rolls, and insert personal data manually at any time.

Circle No. 124 on Reply Card

Industrial Relays

Automatic Electric Sales Corp. Ten data sheets cover complete line of industrial relays which are plug-mounted for advantages in assembly, inspection, servicing and maintenance. Dimensional drawings, wiring diagrams and specifications for five different plug-mounted classes of relays are given.

Circle No. 125 on Reply Card

Turret Indexing Units

Swanson Tool and Machine Products, Inc. Ten-page brochure describes turret indexing units which provide a completely self-contained turret chassis in a wide range of turret diameters, speeds and stations. Standard units with turret diameters of 20, 30, or 40 inches for mounting 16, 24, or 32 work stations, and with indexing rates from 547 to 4,700 per hour are available. Operational data, dimensional details, and sketches of various models are included.

Circle No. 126 on Reply Card

Repeat Cycle Timers

A. W. Haydon Co. Information on new line of miniature hermetically-sealed repeat cycle timers is given in this bulletin. Cycling time, timing accuracy, detail characteristics and determination of timing tolerances complete the material.

Circle No. 127 on Reply Card

Automatic Equipment Installations

Bodine Corp. Twenty-eight page brochure describes 12 actual case histories of how Bodine automatic equipment is used by various manufacturers. Each history gives illustrations of the machine involved and the part made, drawings of the sequence of operations, production capacity, specifications and other data. Machines in installations include automatic multi-spindle machines for drilling, tapping, milling, screw inserting and assembly of small parts.

Circle No. 128 on Reply Card

Automatic Washer for Castings

International Conveyor & Washer Corp.—An automatic indexing, fixture type, three stage industrial washing machine processes 400 castings per hour, externally and internally, and maintains cleanliness of solutions automatically. Four-page bulletin describes machine and its components, complete cleaning cycle, and gives specifications.

Circle No. 129 on Reply Card

Design of Special Purpose Devices

Ram Meter, Inc.—Company specializing in design and manufacture of electrical, electromechanical, and electronic devices has published a 16-page illustrative bulletin setting forth a few of the special purpose items produced for specific clients. These include a "sun" motor which operates on solar energy, remote control systems, thermoswitches, instrument shunts, and accelerometers.

Circle No. 130 on Reply Card

Machine Tool Fixtures

Swartz Tool Products Co.—"Advancing Automation" is title of a new 8-page bulletin describing company's complete services to builders of machine tools, and its facilities for the design and construction of precision work-holding fixtures. Typical fixtures for standard, single station, rotary index, trunnion index, and transfer machines are illustrated with factual data on each.

Circle No. 131 on Reply Card

AUTOMATION

ABSTRACTS

DUAL FREQUENCIES FOR INDUCTION HEATING PROCESSES

R. S. SEGWORTH
General Engineering Co., Ltd.
Toronto, Canada

APPLICATION of induction heating has sometimes been retarded because of the initial cost of the plant. In certain cases, particularly where through heating is required, substantial economies can be secured by using two frequencies rather than one. In other cases, use of two frequencies makes it possible to do a better job or to accomplish a result that would not be possible with a single frequency.

One of the outstanding characteristics of induction heating is the fact that there is no physical contact between the source of energy and the work. Heat is actually generated in the work itself through operation of the alternating magnetic field set up by current in the conductors supplying the energy. This alternating magnetic field generates eddy currents which alone heat the work. Consequently, then, any study of induction heating from a theoretical point of view at least, must consider the performance and characteristics of such an alternating magnetic field.

It can be shown that for solid materials which are to be heated throughout, optimum conditions are achieved when the effective depth of penetration of the magnetic field is equal to about 20 per cent of the diameter of a cylindrical part or 28 per cent of the thickness of a rectangular part. For this relationship the effective depth is considered to be a depth sufficient to accommodate the total magnetic flux if uniformly distributed at a concentration equal to that existing at the surface.

Penetration

Steinmetz has shown that the factors affecting this depth of penetration are:

1. Frequency
2. Resistivity
3. Permeability

With mild steel for example, a very large change in permeability occurs as it is heated. This change takes place at the Curie point, which is generally at about 1400 F. With the field strength commonly used in induction heating work, permeability may change from the order of 10 to 60 to approximately 1. Consequently, it will be apparent that a frequency which would be ideal for temperatures below 1400 F might be much too low when the steel had attained a temperature above this point. Changes in resistivity also occur whenever a metal is heated, but generally such changes are not sufficient to justify a change in the applied induction heating frequency.

Obviously, in actual practice there is a fourth factor in addition to size, resistance and permeability that must be considered in the selection of the best frequency for a given job. That factor is cost—operating as well as first cost. With this in mind and considering through heating, as for the forging of mild steel, it is generally found that when the part is six inches square or larger it is economically as well as practically feasible to heat it all the way to forging temperature, using 60 cycles only. So long as the part is magnetic it is equally feasible to

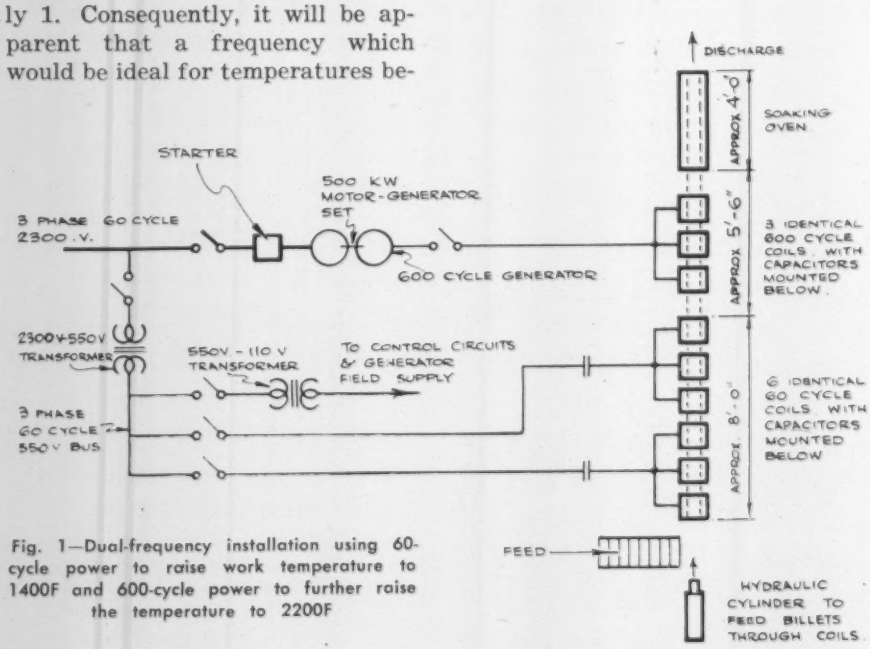
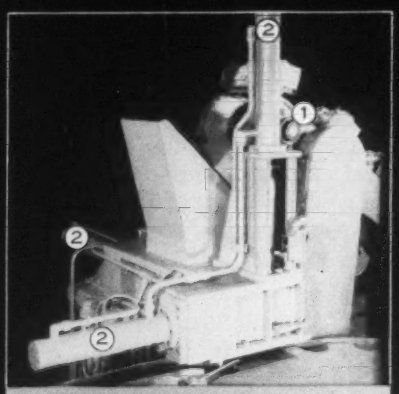

DISCHARGE
APPROX 4'-0"
SOAKING OVEN
STARTER
500 KW MOTOR-GENERATOR SET
3 PHASE 60 CYCLE 2300 V.
600 CYCLE GENERATOR
APPROX 5'-6"
3 IDENTICAL 600 CYCLE COILS WITH CAPACITORS MOUNTED BELOW
2300V-550V TRANSFORMER
550V - 110 V TRANSFORMER
TO CONTROL CIRCUITS & GENERATOR FIELD SUPPLY
3 PHASE 60 CYCLE 550 V BUS
APPROX 8'-0"
6 IDENTICAL 60 CYCLE COILS WITH CAPACITORS MOUNTED BELOW
FEED
HYDRAULIC CYLINDER TO FEED BILLETS THROUGH COILS

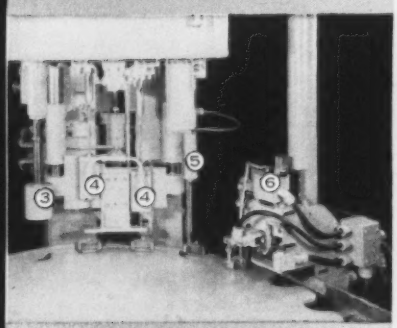
Fig. 1—Dual-frequency installation using 60-cycle power to raise work temperature to 1400F and 600-cycle power to further raise the temperature to 2200F

HOW W. F. & JOHN BARNES SPECIAL EQUIPMENT DESIGNING AND BUILDING SERVICE

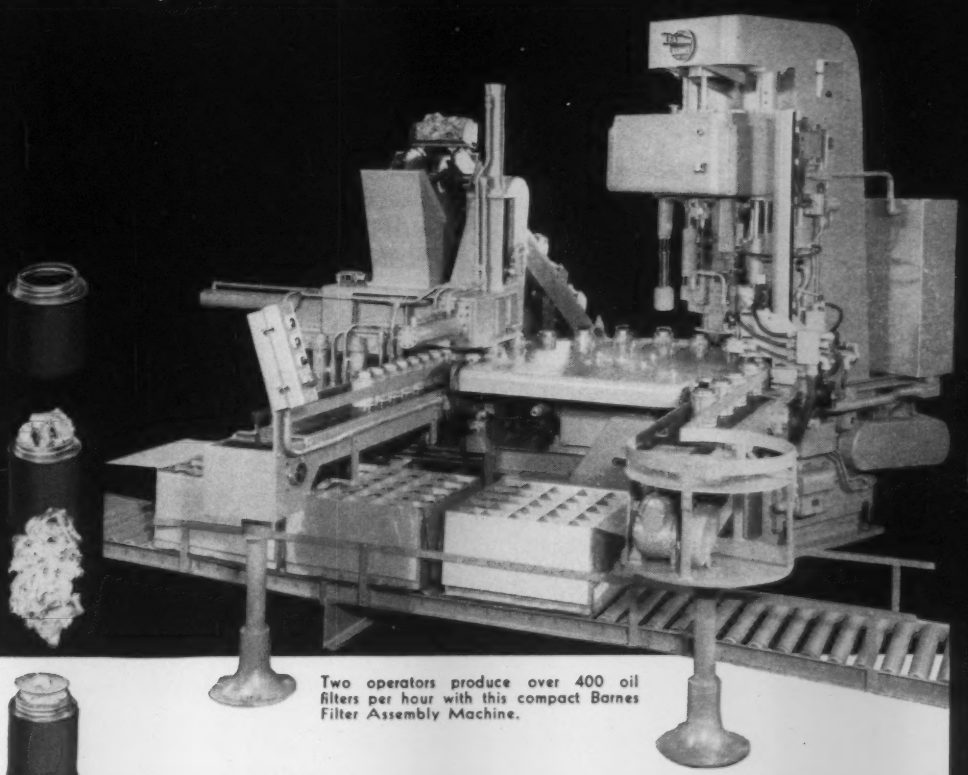
increased production 220% *through* AUTOMATIC ASSEMBLY *of oil filters*



Operator stationed at front of machine feeds empty cans from cartons at the left-hand side. Cans are automatically conveyed to star wheel. Second operator at rear of machine measures cotton waste, which conveyor (1) carries to hopper of compressing and loading cylinders (2). Same operator places wire screen and retainer on filter as it indexes to the next station.



Automatic plunger (3) forces screen and retainer into filter body. Two oscillating air drills (4) weave oil hole through cotton waste. Automatic gauge (5) checks depth of hole, ejecting defective units from machine. Next unit (6) automatically adds cork gasket to complete the assembly. Cartons are moved along conveyor to the discharge side of the machine, where they are repacked with completed filters.



Two operators produce over 400 oil filters per hour with this compact Barnes Filter Assembly Machine.

Oil Filter assembly production boosted from 125 to over 400 units per hour . . . that's the result story of this Barnes Filter Assembly Machine now at work for a large farm implement manufacturer. And equally as important, a higher-quality, more uniform product is being obtained with only one-third the personnel formerly required.

Once again the wide experience of W. F. & John Barnes Process Equipment Division has enabled another manufacturer to substantially reduce production costs and improve product quality. This special machine is only one of many widely diversified types now successfully and profitably cutting costs and increasing production output in hundreds of plants throughout the country.

Here at Barnes you'll find the varied engineering and creative skills, PLUS over 75 years of machine building background, to help you solve troublesome production problems. And because all planning, engineering, and manufacturing efforts are closely coordinated, you have available a complete *Automation Equipment Service* from one convenient and *experienced* source.

ASK TO HAVE YOUR PRODUCTION METHODS ANALYZED

Find out how these unique creative and specialized resources can help you cut costs. Your problem will be given expert and individual attention.

GET THIS *Free* BOOKLET

Write today for your copy of "Coordinated Creative Engineering and Manufacturing" — a 32-page booklet of cost-cutting *Automation Equipment* ideas.

W. F. & JOHN BARNES COMPANY
PROCESS EQUIPMENT DIVISION
321 SOUTH WATER STREET • ROCKFORD, ILLINOIS

W. F. & JOHN BARNES

BUILDERS OF BETTER MACHINES AND EQUIPMENT SINCE 1872

apply 60 cycles directly if it is about 1¼-in. square or larger.

Thus, in the range of sizes between 1¼-in. square and 6-in. square, optimum conditions are achieved by the use of two frequencies, one being 60 cycles to raise the temperature of the part to about 1300 F and the second, a higher frequency appropriate for heating the nonmagnetic steel to the desired final temperature.

Steel Forging

Consider for example a 3-inch square mild steel billet which is to be heated to forging temperature. It would be entirely possible to do this job using, say, 600 cycles all the way. However, it would be more economical in first cost, and also in operating cost, to do the job with two frequencies.

Sixty-cycle power could be used directly to heat this particular billet to approximately 1400 F, using the 600-cycle power only to take it from 1400 F to final forging temperature which might be in the order of 2250 F. On this basis it would be found that one-half of the power could be applied directly, thereby reducing by one-half the amount of equipment required to convert the power from the 60 cycles to a higher frequency. Since the frequency-converting equipment is generally the most expensive part of any induction heating installation, it would be apparent that this offers the possibility of a substantial saving in initial cost.

While it is true that in some cases the 60-cycle coils are more expensive than coils of equivalent capacity and using a higher frequency, and while it is also true that the 60-cycle capacitors necessary for power factor correction are likely to be more expensive than the capacitors required for an equivalent job with higher frequency, these two items together do not approach the cost of the frequency-converting equipment.

Operating Efficiency

There would also be a net gain in over all operating efficiency. This gain is achieved for two reasons. First of all, with two frequencies, the plant would be operating both above and below the Curie point at approximately the optimum condition. Furthermore, only half the power has to be converted and consequently the conversion losses are reduced by a half. In this case, then, the dual frequency method provides a plant which is less expensive and more efficient throughout its operating life.

In one such dual-frequency installation there are two lines, each line heating approximately 6000 lb. of steel per hour. Power consumption as measured at the power company's meters, so that all losses for both conversion and transmission are included, is approximately 800 kw per line. Initial cost of the equipment was also very favorable, being less than $125,000 per line completely installed and ready for operation. In this installation, 3-phase 60-cycle power at the regular plant voltage is applied directly to the coils at the beginning of the heating line. These coils raise the temperature of the steel as it passes through them to approximately 1400 F. The second half of the line is supplied with power at 600 cycles and in these coils the work is raised to temperature of about 2200 F. A general arrangement of the setup is shown in *Fig.* 1.

A somewhat unique application for dual frequency has been developed for the heat treatment of shells. In this case it is necessary to bring the entire shell to a temperature of approximately 1550 F prior to quenching. Owing to its shape, with relatively thin walls and a thick solid base it was found to be impossible to achieve a uni-

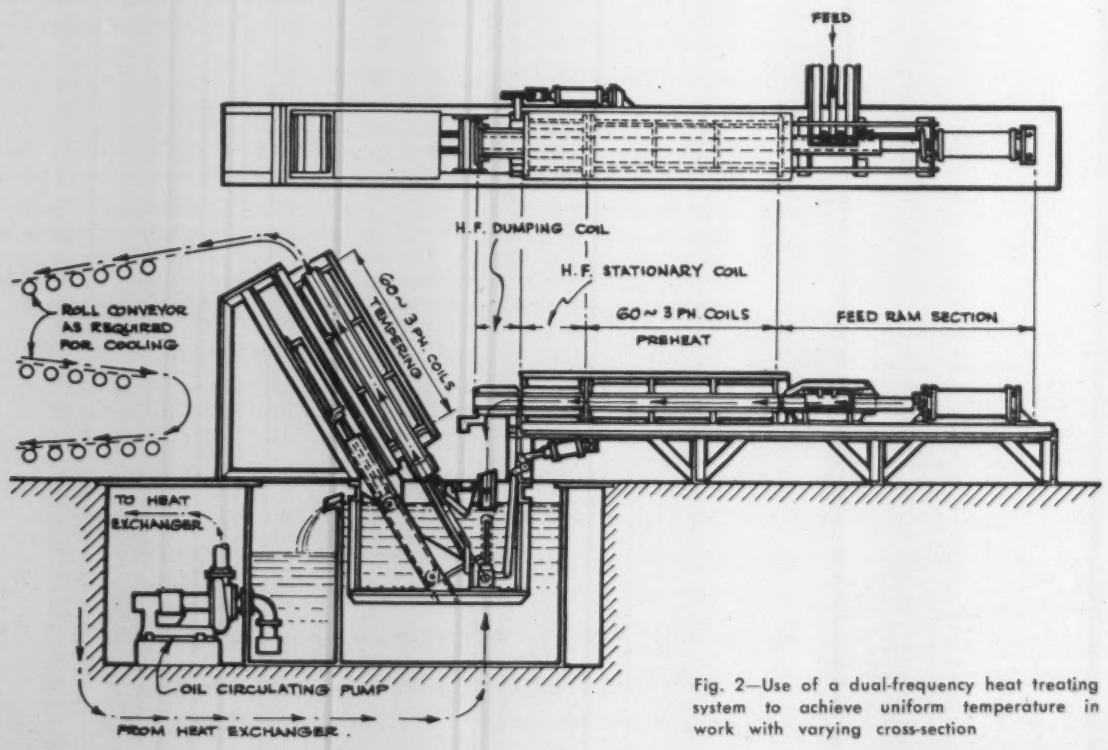


Fig. 2—Use of a dual-frequency heat treating system to achieve uniform temperature in work with varying cross-section

form temperature with a single frequency. However, by applying two frequencies, satisfactory results have been achieved. In this case, 60-cycle power is used to bring the thin wall sections to approximately 1400 F and to bring the thick base section to a somewhat higher temperature. The second frequency was very carefully selected so that the heating effect was distributed between the thick base section and the thin walls in such a way that all parts reached a 1550 F temperature uniformly. In this case, the heating was followed with an oil quench and a draw at approximately 1100 F. Sixty-cycles only was found to be adequate for the draw operation. This installation has been in operation for nearly two years and the product has been remarkably uniform and satisfactory. This installation is diagrammed in *Fig.* 2.

From a paper entitled, "Process Applications For Dual-Frequency Induction Heating" presented at the Annual Meeting of ASTE in Philadelphia, April, 1954.

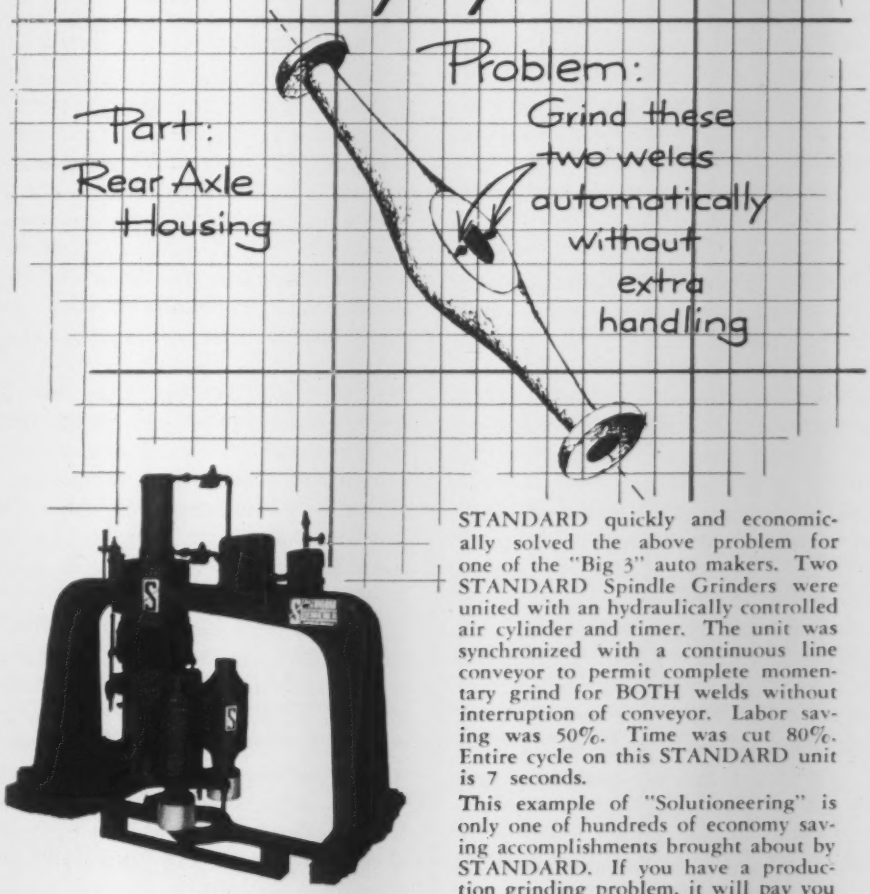
AUTOMATION IN THE STEEL INDUSTRY

J. W. PERCY
United States Steel Corp.
Kearny, N. J.

STEEL INDUSTRY is cognizant of changes and improvements in control that have taken place in the last decade. Most of these changes and improvements are really the application of new commercial devices that have been offered by the instrument manufacturers or others alert to the possibilities in instrumentation. No attempt will be made to describe these devices in detail. All are available commercially and complete descriptions may be obtained from the manufacturers or from the technical literature. At the moment, these changes appear to have brought about an improvement in the quality of product, rate of production, and greater uniformity in the operation of the process.

The chemical composition of the products of combustion, the flue gases, is of interest in the operation of the open-hearth furnace. At

"Solutioneering" by STANDARD



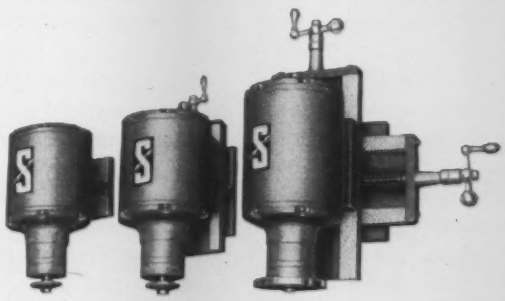
STANDARD quickly and economically solved the above problem for one of the "Big 3" auto makers. Two STANDARD Spindle Grinders were united with an hydraulically controlled air cylinder and timer. The unit was synchronized with a continuous line conveyor to permit complete momentary grind for BOTH welds without interruption of conveyor. Labor saving was 50%. Time was cut 80%. Entire cycle on this STANDARD unit is 7 seconds.

This example of "Solutioneering" is only one of hundreds of economy saving accomplishments brought about by STANDARD. If you have a production grinding problem, it will pay you to consult STANDARD today.

Write for catalog.

Standardize with
the STANDARD electrical tool co.
PRECISION SPINDLES • MACHINE TOOLS
2550 RIVER ROAD • CINCINNATI 4, • OHIO

CHECK STANDARD's COMPLETE LINE OF PRECISION SPINDLES



WRITE FOR COMPLETE CATALOG

a certain stage in the melting process, considerable gaseous carbon monoxide, CO, is evolved from the bath. This gas is potential fuel provided that sufficient air is present at the time to burn it. To make this utilization requires a varying amount of combustion air, depending upon the amount of oxygen present in the waste gases. This necessitates the continuous determination and recording of this quantity.

It would be highly desirable further to make this whole utilization of the CO an automatic procedure, by controlling the oxygen content of the waste gases through automatic adjustment of the fuel-air proportioning control by means of an oxygen analyzer working on the waste gases. Many such experiments have been and are being carried out. Considerable difficulty has been encountered in obtaining a cleaned sample of gas. The presence of slag, scale, refractory material and dust in the waste gases plugs up the sampling tube in a short time, cutting off the supply of sample gas to the analyzer.

At this time, at least two new types of sampling tubes are under test, both of which look promising. In one of these installations, the oxygen content of the waste gas has been controlled at a constant value of about 1½-per cent for a period of several hours, which is certainly a step in the right direction. It appears to be only a question of time before it will be possible to install such control on any open hearth furnace.

Rolling

To our knowledge, the only temperature information not now obtainable in the rolling process is the mill-finishing temperature on rod having a diameter less than ⅜-in. This is due to the fact that none of the radiation-sensing devices now manufactured will operate satisfactorily on so small a target, allowing for some lateral motion of the rod being rolled at very high speeds. A number of ideas along this line have been tried, thus far with little success.

In the continuous rolling strip, wired television has been used to advantage in two mill locations. The operator who manipulates the equipment employed to charge slabs into the reheating furnaces is stationed in a pulpit centrally located opposite the charging end of the middle or second of three furnaces. He has no difficulty in aligning the slab to be charged into the middle furnaces, but the alignment of the slabs entering the outside or first and third furnaces requires the services of one or two extra men. To simplify this situation, a kinescope has been set up at the charging end of each of these outside furnaces so that the outside end of the charging line of the slabs is in view of the scope. These two scopes are connected to two monitors or screens placed in front of the operator in the pulpit. Every movement of the slab is plainly visible to him, and rapid alignment of the slab for charging is brought about.

The second location in which wired television is used on the strip mill is near the center of the run-out table, between the finishing stand of the mill and the coiler, where the hot-rolled strip is wound up into large coils. The strip leaves the finishing stand of the mill at a rate of about 2000 fpm and approaches the coiler at this same rate. A kinescope erected above the roll table and sighted towards the coiler is connected to a monitor in an adjacent pulpit.

Here the operator of the last stand screw-down controls is able to correct any tendency of the strip to camber or move out of alignment with the coilers. By watching his monitor and the image of the moving strip, he is able to make the strip enter the coilers squarely and in line throughout its entire length. This prevents cobbles and uneven coil sides which minimizes scrap coils and down time on the mill.

The matter of continuous gaging on the strip mill had been a serious problem until the last two or three years. Several years ago, thickness measurements were made with hand micrometers either on small pieces cut from the strip or on the edge of the strip, with the strip held stationary in the mill. Later, contact gages of the magnetic or solenoid type improved the situation. With these, continuous measurements were possible, but because of the vertical motion of the strip, the measurements were not as accurate as desired. With the advent of the X-ray gages a solution was found.

While these gages are expensive and require considerable maintenance, they are very accurate, noncontacting, and their accuracy is not affected by slight vertical motion of the moving strip. Until very recently, these X-ray gages recorded only the plus or minus deviation from the desired thickness. The necessary adjustments were made manually by one of the mill operators.

Very recently, experiments have been made in which the X-ray gage, in addition to recording the deviation in thickness of the strip, has been connected through accessories to the screw-down drive on the finishing stand on the mill, and the compensating adjustments are made automatically. The system is not completely satisfactory since two screw-downs are involved to prevent camber but is very promising. With some changes and continued experience it seems only a question of a short time until this problem is solved.

One of the newest electronic devices to find its "place in the sun" around the hot-strip mill is a width gage. This instrument has two scanning heads, the desired width of the strip, is adjusted manually by the operator. The width gage then indicates and records any deviation in this distance to a very small fraction of an inch. Thus far, width adjustment in the strip is not made automatically but here again it seems to be only a question of development.

Finishing

In our present economy, much of the hot-rolled steel such as strip must be treated further to fit the consumers' needs. It may be annealed, blued, tinned, cold-reduced, cold-rolled, or receive heat treatment to change its physical properties or characteristics. It may be annealed or softened either as coil or in the flat condition. Until a very few years ago, sheet and

strip annealing was done in batch-type furnaces, and much of it is still done in that manner. Within the last four years, however continuous annealing has been introduced in several plants in this country. This requires a furnace of tremendous size, approximately 250 ft long and 60 ft high with pits 36 ft deep. Roughly 1500 ft of strip are in the furnace at one time, moving at rates up to 1000 fpm. That means that the strip is heated to more than 1300F and cooled at the proper rate back to a bit over room temperature in about 2 minutes. Part of this cycle is carried out in a special gaseous atmosphere that will preserve the bright finish on the strip. All of this requires extremely effective rapid control of speeds, temperatures, cooling media, tensions, and atmospheres.

The tin plate which is used by the canning industry, either for foods or for other products, is made by two methods. Approximately one-quarter of the total tonnage is made by the hot-dip process, which has been used for many years. In the beginning separate sheets were dipped by hand into molten tin. This dipping is now done mechanically by feeding the individual sheets through a bath of molten tin, then through a bath of molten palm oil to freeze the tin remaining on the sheet and finally through a shower of bran to remove the excess palm oil. Very few new controls have been applied to this process for some time.

The other three-quarters of the tin-plate tonnage is manufactured by electrolytic means; that is, the tin is electroplated upon the strip as it passes through a liquid plating bath at a fairly high rate of speed. In this electrolytic process a number of variables, such as speed of the strip, temperature and concentration of the chemical plating bath, and so on, are all controlled either automatically or semiautomatically. This type of plate may have a normal or a very thin coating of tin, which can result in a large saving of that sometimes very scarce material.

This plate is made in a continuous process and before removal from the tinning line the large coils pass through another type of machine where these coils are cut at a very high rate of speed into individual sheets by a rotating shear. As the pieces leave the shear, each piece passes another electronic device, which counts and records the number of pieces so that an exact number may be placed in packages for shipment. All tin plate must be examined for small holes and other such imperfections. This is done automatically and continuously by special electronic devices.

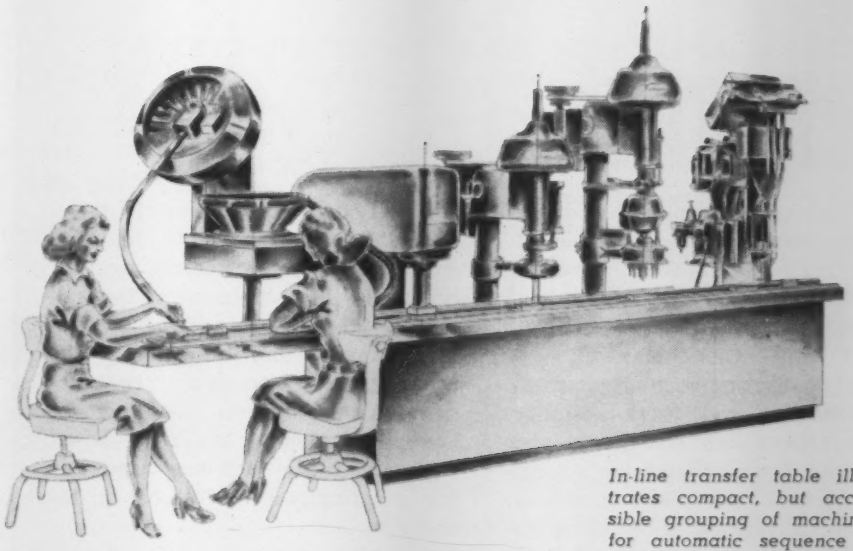
These machines not only will detect the presence of small imperfections but will extract automatically the imperfect plate from the line and place it in the scrap bin. The amount of coating on such electrolytic tin plate is very thin, as little as 0.00003-in. thick, but even this thin coating is controlled, by the use again of X-ray gages. These measurements are exceedingly accurate and are made very rapidly so that the process is always under excellent control.

For the fabrication of such

DIXON *Automatic* **ASSEMBLING MACHINES**

Parts *Automatically* **transferred to successive machining operations**

Can be equipped with hoppers, loaders, presses, welding and soldering devices, riveters, screw drivers, and nut runners.



In-line transfer table illustrates compact, but accessible grouping of machines for automatic sequence of operations.

WRITE FOR FREE INFORMATION

Automatic secondary operations can lower your production costs.

DIXON *Automatic Tool, Inc.*

2303 TWENTY-THIRD AVE.

ROCKFORD • ILLINOIS

things as automobile bodies and other so-called deep-drawn articles, steel sheet must be specially prepared. To obtain the proper physical characteristics and to prepare a very smooth surface for painting, such sheets are cold-reduced; that is they are rolled to a thinner gage at room temperature or slightly above.

During this cold reduction the sheet also is extended in length. In fact, this extension is a measure of the amount of cold reduction. Here automatic electronic equipment again comes into use. The pressure of the cold-working rolls and the amount of elongation or extension of the sheet are measured with extreme accuracy. The exact thickness or gage of the sheet or strip is measured with an X-ray, a device very much similar to the one used in measuring the gage of the hot-rolled strip mentioned previously. Here again, recent experiments have been made in which the thickness of the sheet is adjusted automatically by the X-ray gage with the use of auxiliary equipment. These experiments are even farther along than those in the hot-rolling process and are very promising.

In the foregoing discussion, no attempt has been made to cover all of the new devices or new applications in instrumentation that have been used in the steel industry during the last ten years. To do so would take far more than the time allotted here. The almost phenomenal increases in production rates have made the use of manual controls almost obsolete. One strip mill alone increased its output from about 1,700,000 tons in 1949 to more than 3,000,000 net tons in 1953. The use of multiple fuels on heating furnaces has complicated the control problem further, particularly in metering. Increases in the physical size of the plants themselves have necessitated the use of considerable telemetering, and so on throughout the whole steel process. The few items mentioned have been those which seem to stand out in their effectiveness, enough to deserve specific consideration.

From a paper entitled, "Ten Years of Progress in Instrumentation in the Steel Industry," presented at the Instruments and Regulators Conference of ASME in Philadelphia, Sept. 1954.

UNIFIED APPROACH TO REGULATING SYSTEMS

R. H. MACMILLAN
Cambridge Univ.
Cambridge, England

FIRST extensive application of automatic control was to a speed-regulating system—the governor designed by James Watt to control his steam engine. A century passed before Clerk Maxwell published the first mathematical study of governors and their stability. It was almost half a century later still that Nyquist and his associates devised the more powerful methods of frequency-response analysis for the treatment of such systems.

These methods were applied originally to feedback amplifiers and position-control systems, rather than to the design of regulators, which are defined in this paper according to British practice as control systems which maintain automatically at a fixed value the magnitude of some variable (usually engine or turbine speed) against relatively high-frequency disturbances. Meanwhile another group of engineers had been using automatic devices to control processes, and had arrived at some of the same design methods by a different route and disguised under a completely different terminology.

Recent Trend to Mathematics

Until comparatively recently governors and process controllers were designed without any detailed analysis of their action when considered as part of a closed-loop system. This was possible because the control required of them was not to very close limits and because they did not need to be particularly quick acting; that is, they did not have to respond to high frequencies. As the performance demanded becomes more exacting, however, and the sensitivity of the control is correspondingly increased, a stage is reached where self-oscillation of the system occurs. To obtain close control while avoiding the onset of such instability, a mathematical investigation becomes an essential preliminary to design, for only by this means it is possible to meet more stringent specifications.

Such analysis cannot, of course, replace the development stage of a design, but it guides and supplements it. Frequency-response methods not only enable the designer to estimate the performance of a proposed system, which is the normal function of analysis; they also can assist him, to some extent, in the far more difficult problem of synthesis which aims to provide means for designing a system to meet a given specification. They even may go a step further and indicate the best performance obtainable within given physical and economic limitations.

Fundamental Methods

The present situation is that analytical methods for linear and quasilinear systems have oustripped practical development in all but the most advanced designs. The mathematical tools available to the designer are thus sufficient to enable him to make a full analysis of a linear control system provided that he can determine the necessary characteristics of its elements.

The latter is one of the stumbling blocks which current research aims to remove. However, all engineers concerned with control systems will not be able to derive the full benefit from these powerful methods until it is generally appreciated that many of the problems faced by these different groups are fundamentally similar and that consequently, the same methods are suitable for their solution.

Mathematical techniques provide just such a unifying basis, for they undoubtedly can lead not only to a uniform and rational approach to control problems, but also to a consistent nomenclature, based on the mathematical processes involved. This process of unification might be compared with that successfully achieved by the early chemists in bringing order out of the work of their alchemist predecessors, who used half a dozen different names for the same substance, according to the way it happened to have been made.

Stages of Analysis

This approach, common to the study of all closed-loop systems, divides sharply into three stages. The first is the description of the physical system by means of a block diagram and transfer-function technique. The transfer function of an element describes concisely its frequency-response characteristics. If small disturbances about an equilibrium position of the system are to be considered, it is possible to use a linearizing technique for some of the nonlinear elements.

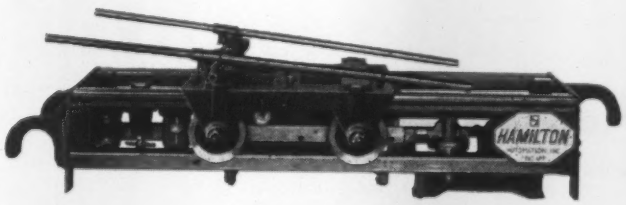
After analytical expressions have been derived for the transfer function of every element, an equation of motion for the system can be written down. It often happens in practice that the frequency response of an element is known only empirically. In such cases, either the best mathematical approximation may be taken as the transfer function or the available harmonic-response locus may be used directly without determining analytically an explicit equation of motion.

The next stage of this unified approach is the analysis of the information thus obtained. This enables one to predict the response of the system to various typical disturbances and thus to compare its performance with that of other systems, by applying suitable (or mathematically convenient) criteria. This completes the process of analysis. The final stage is synthetic; methods are available for altering the coefficients and form of the equation of motion in such a way as to improve the performance of the system. This process of adjustment will present considerably greater difficulties in its application to some systems than to others, but it is inherent in all rational design.

All control systems are governed by equations of motion which are liable to become inadequately damped or even unstable for certain values of the system parameters. Therefore there is no fundamental objection to the use of a uniform approach, both for obtaining the equation of motion and for its analysis.

Process and Position Control

In process control the main problems consist in finding an adequate representation for the behavior of the load and the practical difficulty of making a measurement of the value of the controlled variable, which will permit a direct comparison with its desired value. Various delays are usually involved



HAMILTON AUTOMATIC AIR SHOVEL

PULL PARTS

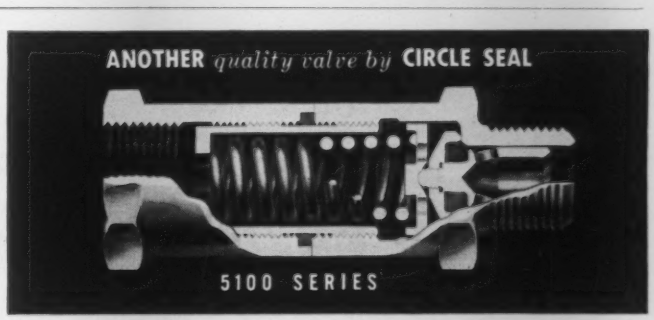
Automatically

FROM

PUNCH PRESSES

Hamilton Automation Inc.

HAMILTON, OHIO



After two years of research

A RELIEF VALVE THAT DOESN'T LEAK!

- In-line design
- Adjustability that can't be tampered with
- Excellent flow characteristics
- Precise operating reliability
- Suitable for almost any gas or liquid

Send for information today..... ☐

CIRCLE SEAL *precision valves*

Representatives in Principal Cities.

JAMES•POND•CLARK

2181 East Foothill Blvd • Pasadena 8, California

in the latter process, which must vitiate the performance of the system as a whole. The time constants of the load and of the disturbances are, however, relatively large when compared with those of the controlling mechanisms, so that inertia in the controlling apparatus is of secondary importance and the speed of response need not be pushed to the limit.

In position control, on the other hand, the system must respond to a rapidly fluctuating input signal and, the sensitivity of the control being correspondingly high, the time lags in the servomechanisms are often the dominating factor. In addition, the control must attempt to distinguish between genuine input signals, requiring motion of the load, and spurious signals, usually of high frequency, superimposed upon them.

Speed regulation involves some of the problems of each of these fields. The response must be rapid, so that the sensitivity must be high and the considerable difficulties involved in the rapid measurement of speed, together with the delays inevitably associated with the changing of the engine-power output, are apt to lead to instability.

Until quite recently the problem of speed measurement has occupied too important a place in the minds of those concerned with engine governing. This is even more true of the textbooks at present available, which are concerned exclusively with the properties of governors and are almost regardless of the fact that the governor is only the measuring element in a complete closed-loop system. The emphasis, happily, is now shifting to the wider outlook.

Results of Basic Approach

The design of automatic pilots for aircraft affords an interesting example of a control with the dominant characteristics of a regulation problem, which has been handled successfully by the techniques normally reserved for position control. Nothing but good has come from this fusion of ideas.

These minor distinctions between the problems confronting control engineers in the various fields can no longer justify the radically different terminology which they still normally adopt. Progress in the past might have been more rapid had those concerned appreciated, for example, that an "inverse Nyquist diagram" and a "Potential correction curve" are essentially the same thing. It is time for general replacement of such primitive expressions as "temporary return motion," "transient reset" and "proportional bandwidth."

Only when the ground has been cleared in this way will engineers be in a position to make full use in their own particular field of the various techniques for analysis and synthesis which have been devised during the last decade. Standard glossaries of terms, collating the different usages, already have been prepared both in Great Britain and in the United States.

From a paper entitled "Analysis of Regulating Systems with Particular Reference to Speed Control" presented at the Annual Meeting of ASME in New York, Nov.-Dec. 1953.

MAGNETIC AMPLIFIER CONTROLLED TANDEM MILLS

J. W. BRINKS
Westinghouse Corp.
Pittsburgh, Pa.

J. C. PETH
Pittsburgh Steel Co.
Monessen, Pa.

ANYONE associated with the iron and steel industry knows that when steel mill equipment is purchased it almost invariably represents the most modern equipment available to perform the function for which it has been purchased. Emphasizing this is the increased use of magnetic amplifiers on suitable regulating system applications. Perhaps the most notable of the new applications of magnetic amplifiers is their use as the complete generator regulation and excitation components of tandem cold strip mill control.

Early this year, a 66-inch wide four-stand tandem mill was put into service at the Allenport plant of Pittsburgh Steel Co. The mill, having a nominal delivery speed of 3190 fpm, has a total stand and reel connected horsepower of 17,700. Individual generators supply power to each stand and reel.

The voltage of each stand generator is matched to a common reference bus through a 400-cycle magnetic amplifier voltage regulating system. Any difference between generator and reference voltages will cause a corrective signal in the control winding of the regulator. An *IR* drop magnetic amplifier introduces a compensating signal into the control circuit to compensate for stand motor *IR* drop.

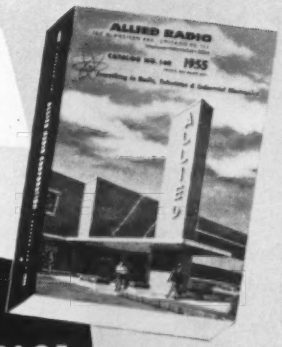
The ordinary run of magnetic amplifier applications utilizes a 60-cycle, ac supply system. But the fast response and high accuracy requirements of the tandem mill regulating system led to the development of a 400-cycle magnetic amplifier tandem mill control. Since the response time of the magnetic amplifier is inversely proportional to the supply frequency, the advantage of the 400-cycle system can be readily appreciated.

The performance of the Pittsburgh Steel tandem mill and the results of extensive computer studies and factory tests have served to point out the improvements resulting from the complete use of magnetic amplifier regulating systems on tandem cold strip control.

From a paper entitled "Operation of Magnetic Amplifier Controlled Tandem Mills" presented at the Association of Iron and Steel Engineers Convention in Cleveland, Sept. 1954.

the most widely used
Electronic Supply Guide

free send for it



ALLIED'S
COMPLETE 308-PAGE
1955 CATALOG

your guide to the world's largest stocks of
ELECTRONIC SUPPLIES FOR INDUSTRY

Simplify and speed *all* your purchasing of electronic supplies and equipment. Send your orders to us for fast shipment from the world's largest stocks of electron tubes (all types), test instruments, audio equipment, electronic parts (transformers, capacitors, controls, etc.). Our expert Industrial supply service saves you time, effort and money. Send today for your FREE 1955 ALLIED Catalog—the *complete* up-to-date guide to the world's largest stocks of quality Electronic supplies for Industrial use.

One complete dependable source for everything in electronics

ALLIED RADIO
100 N. Western Ave., Dept. 80-L-4
Chicago 80, Illinois

Write today for your free copy of this Technical Paper.

ask for data file 1112

The Precision Potentiometer as a Voltage Divider

BY H. A. SCHMIDT
Sales Engineer, Helipot Corporation

Reprinted from PRODUCT ENGINEERING:
Annual Handbook of Product Design for 1954

389

Helipot *first in precision potentiometers*

Helipot Corporation / South Pasadena, California
a division of BECKMAN INSTRUMENTS, INC.

NEXT MONTH IN

Automation Opens New Vistas for Stampers . . . *Francis J. Sehn*
Modern Egg Handling . . . . *(Pictorial)* **. . . . Automation Today**
Hydraulic and Pneumatic Servos . . . . Part 3 . . . *R. Hadekel*
Integrated Data Processing Through Common Language . . . *P. B. Garrott*
Automatic Production Gaging . . . . *Albert C. Sanford*
Automatic Control Terminology . . . . Part 5
Spline Rolling Can Be Automated
Feedback Regulates Voltage . . . . *M. C. Holtje*
Electronic Controls Regulate Refinery

And many more idea-packed articles! For complete index of articles which have appeared so far in Automation, see page 114

CUMULATIVE EDITORIAL INDEX

Number preceding the hyphen is month of issue; those following are page numbers in that issue.

A

Abrasives manufacture, coated, **8**-62

Absorption, radiation, **9**-47

Accounting, **8**-66

Air gaging, **8**-76; **11**-21

Aircraft,
automatic pilot, **8**-129
control, **8**-55
engines, **8**-39; **9**-113

Amplifier,
magnetic, **9**-105; **11**-112, 116
servomotor, **9**-49

Analog computer, **9**-68; **10**-96
heat transfer, **9**-34

Analog to digital conversion, **10**-41

Analog vs digital computer, **9**-63

Analysis,
mathematical, **11**-110
process stream, **11**-46

Analyzer,
infrared, **9**-47
yarn, **9**-70

Armature manufacture, **10**-21, 105

Assembly, **8**-39, 120, 124; **9**-22, 109; **10**-23, 53; **11**-12

Atomic energy, **9**-69

Atomic Energy Commission, **9**-107

Atwood, S. G.
Layout for Handling, **10**-46

Automatic control, **10**-108
basic characteristics, **9**-65
discontinuous, **8**-139
principles, **8**-138
terminology, **8**-61; **9**-65; **10**-51; **11**-59

Automatic elevator, **9**-68; **10**-104

Automatic machines, **8**-34; **9**-109

Automatic systems, **11**-47

Automation,
application of, **9**-21
benefits of, **8**-50
concepts, **10**-100
definition of, **8**-34, 46, 156; **10**-18
development of, **8**-46; **9**-20
elements of, **8**-35
history, **10**-102
in the office, **10**-50
job shop, **10**-46
planning for, **8**-35, 37, 49, 50; **9**-22; **10**-18, 47
process design for, **8**-132
product design, **8**-72; **9**-23, 51; **11**-18
steel industry, **11**-107

Automobile manufacture, **8**-48

Auxiliary operation, **11**-30

B

Balancing, **10**-38

Behrend, R. H.
Assembling Low-Budget Jobs, **10**-53

Berg, R. H.
Continuous Weighing of Solids, **11**-39

Bin, weighing, **11**-39

Binary number system, **8**-76, 78; **10**-42

Bishop, L. J.
Latex to Foam Rubber, Automatically, **11**-31

Bolz, R. W.
The New Automation, **9**-14
No Robots Here! edit. **11**-17
Design for Manufacture, **11**-18

Bonding, induction heat, **9**-72

Bottle sealing, **11**-23

Bratton, E. W.
Continuous Gaging, **8**-62

Broaching, **11**-14

C

Camera, **11**-14

Capacitance, **9**-65

Capacitors, electronic, **10**-109

Capacity, **9**-65

Cards, punched, **8**-82, 125, 130; **10**-9

Casting, **10**-19

Chemical measuring, **8**-120, 124

Chemical plant engineering, **8**-150

Circuits,
control, **8**-142; **11**-116
etched, **10**-11
printed, **8**-124
servoamplifier, **11**-64
switching, **9**-113

Cleaner, ultrasonic, **9**-72

Clock, setting mechanism, **9**-110

Closed-loop,
concept, **10**-57
systems, **11**-111

Clutch,
electric, **8**-129
electromagnetic, **9**-71

Coin,
collecting device, **9**-109
controlled timer, **9**-109
operated device, **9**-109
weighing device, **10**-38

Commutators, **9**-109

Components, feedback systems, **9**-60

Compounding, rubber, **9**-50

Computer, **8**-68, 129; **9**-108
analog, **9**-34; **10**-96
digital, **8**-141; **10**-108; **11**-9
consultant, **9**-66
control, **8**-74
elements, **10**-97
feedback systems, **9**-62
mechanical, **10**-96

Condenser manufacture, **10**-20

Contacts, electrical, **10**-13

Container, decorating, **9**-37

Contents, **11**-3

Continuous production, acetylene, **9**-64

Control,
aircraft, **8**-55; **9**-113
circuits, **8**-142
closed-loop, **9**-58; **10**-96, 101
computer, **8**-74
electrical **8**-51, 55, 129; **10**-104; **11**-116
electronic, **8**-80; **10**-28, 34, 39, 44
feedback, **8**-58, 63; **9**-57
film, **8**-82; **9**-66
hydraulic, **8**-129; **10**-104
instrument, **8**-58, 122, 129; **9**-108
machine, **10**-98
mechanical, **8**-55
motor, **8**-129
open-loop, **9**-58; **10**-96
photoelectric, **8**-60; **10**-35
playback, **8**-79
pneumatic, **10**-34; **11**-116
power required by, **8**-80
quantitative, **8**-59
tape, **8**-77, 130; **10**-28
temperature, **8**-122; **10**-104
tension, **8**-58; **9**-106
terminology, **8**-61; **9**-59, 65; **10**-51; **11**-59
timer, **8**-140
tool, **8**-51; **9**-44
traffic, **8**-122

Controllers,
automatic, **8**-61
relay operated, **8**-61
self operated, **8**-61

Conversion analog to digital, **10**-41

Conveying, **10**-47

Conveyors, **8**-60, 120, 132; **9**-67, 70; **10**-35, 105; **11**-34
belt, **8**-48, 75; **9**-109
chain, **8**-130; **9**-109
overhead rail, **8**-38
weighing, **11**-39

Crusher, continuous process, **9**-64

Cutoff machine, **8**-131

D

Data processing, **8**-66, 82, 123, 130; **9**-70, 108; **10**-9, 12, 41; **11**-9, 22

Dead time, **9**-65

Design, **11**-116

Digital computers, **8**-141; **10**-108; **11**-9

Digital vs analog computer, **9**-63

Discontinuous automatic control, **8**-139

Drive electronic variable speed, **10**-44

Drum, memory, **8**-67

E

Economics, **8**-35, 36, 51, 73, 148; **9**-15, 22, 28, 113; **10**-27

Education automation, **9**-70

Egg cleaning, **9**-109

Electrets, **10**-109

Electrical,
control, **8**-51, 55; **10**-104; **11**-116
engineering, **8**-140
power, **10**-17
transmission, **10**-103
weighing, **11**-40

Electronics,
capacitors, **10**-109
control, **8**-80; **10**-34, 39, 44
measuring, **8**-131
modular design, **11**-19
servo, **11**-60
tube, **10**-8

Electroplating machine, **11**-12

Electrostriction, **9**-68

Elevator, **9**-68; **10**-104

Engine manufacturing,
aircraft, **8**-39
automobile, **8**-48
diesel, **8**-120

Engineering,
analysis, **9**-112
chemical plant, **8**-150
electrical, **8**-140
instrument, **8**-140
manufacturing, **8**-54
systems, **11**-47
timing, **8**-140

Equipment replacement, **8**-150

Experimental method, **10**-108

F

Feedback, **8**-58, 61, 63; **10**-57, 98; **11**-49
control, **9**-57
speed control, **9**-61

Feeders, **9**-23; **10**-52, 104; **11**-116
vibratory, **8**-76

Film control, **8**-82; **9**-66

Finishing, **8**-122
steel, **11**-108

Flowmetering of solids, **11**-39

Foam rubber, **11**-31

Foundry automation, **9**-100

Furnace, open hearth, **11**-108

G

Gaging, **8**-122
air, **8**-76; **11**-21
gear, **9**-46
radiation, **8**-62; **9**-107; **11**-108
radioisotope, **9**-67
weighing, **8**-59; **9**-27

Gear shapers, film controlled, **8**-82
Gear shaving and gaging, **9**-46

Graphic panel, **9**-18

Gyro, **8**-55

H

Hadekel, R.
Hydraulic and Pneumatic Servos, **10**-57; **11**-49

Hagen, G. E.
Automatic Information Storage, **8**-66

Hagerman, L.
Attachment Automates Container Decorating, **9**-37

Handling,
aligning, **8**-130
conveying, **8**-38, 130; **9**-108, 109; **10**-35, 47, 105
data, **8**-66, 123; **10**-9
feeding, **8**-76; **9**-20, 108; **10**-52, 104; **11**-116
orienting, **8**-130; **10**-35, 104; **11**-20
parts, **11**-58
radioactive, **9**-41
sorting, **8**-75, 76; **10**-38, 104

Harder, D. S.
Automation A Modern Industrial Development, **8**-46

Hardness testing, **11**-10

Hauk, E.
Attachment Automates Container Decorating, **9**-37

History, automation, **10**-102

Hopper, weighing, **11**-39

Howard, S. R.
Weight Controlled Volume Filling, **9**-24

Hunting, **10**-100

Hurni, M. L.
Increasing Automation Opportunities, **8**-69

Hydraulic, **9**-41
control, **10**-104
elements, **9**-42
presses, **10**-53
servos, **10**-57; **11**-49
systems, **9**-45
weighing, **11**-40

I

Index, turret, **9**-39

Indexing, **8**-146; **9**-108; **10**-53; **11**-62, 116

Induction heating, **11**-104

Inspection, **9**-21; **10**-28, 38

Instrumentation, **9**-113

Instruments, **9**-17
control, **8**-58, 129
engineering, **8**-140
measuring, **8**-131
seismological, **8**-141

Interchangeable manufacture, **11**-18

J

Job Shop Automation, **10**-46

Johnson, E. S.
Machine Mobility, **9**-29

Johnson, R. N.
Electrical Maintenance in Automation, **9**-40

Joint Industry Conference, **8**-52

K

Kendall, J.
Remote Handling With Hydraulics, **9**-41

Knapp, H. M.
Design for Automatic Production, **9**-51

Kraus, C. E.
Management's Stake in Automated Handling, **9**-20

L

Labeling, **8**-132

Labor, 8-53; 9-13, 14

Lathes, tape controlled, 8-82

Lift truck, 11-58

Light, 10-17

Limit switch, 9-108

Lindholm, P.
Feedback Control Systems, 9-57

Lubrication systems, 8-64

M

Machine control, 10-98

Machine mobility, 9-29

Machine tools,
automatic positioner for, 8-131
boring and facing, 10-10
broaching, 11-14
fixture, 10-12
gear shaper, 8-82
hydraulic press, 10-53
milling, 8-81; 9-109; 10-26
power brushes, 10-12
screw slotter, 10-44
transfer, 8-47, 146, 148; 9-101
welding, 10-26

Machines,
assembly, 10-23
automatic, 8-34, 77; 9-109
bottle decorating, 9-38
capping, 8-131
condenser winding, 10-20
cutoff, 8-131
electroplating, 11-12
extrusion, 10-105
molding, 8-131; 9-109; 10-105
mounting of, 9-33
repair of, 9-29
tape controlled, 8-77
textile, 8-78

Magnetic amplifier, 9-104; 11-112

Magnetic memory, 8-67

Maintenance, 8-52, 64; 9-29
electrical, 9-40

Management, 8-34, 53, 69, 144; 9-13, 16, 20

Manual control, 10-108

Manufacture of,
abrasives, 8-62
aircraft engines, 8-39
armatures, 10-21, 105
automobiles, 8-48
automotive condensers, 10-20
commutators, 9-109
electronic components, 8-124
electronic tubes, 10-8
lamps, 9-108
screws, 10-44
sheave and bracket, 10-53
starter brush end plate, 10-52
telephone relay, 9-51

Manufacturing engineering, 8-54

Marking, labeling, 8-132

Marvin, P. R.
Automatic Machines At Work, 8-34
Engineering Automatic Systems, 11-47

Mass production, 11-18

Materials, dielectric, 11-116

Measuring,
chemical, 8-120, 124
electronic, 8-131
flatness, 9-109
gaging air, 8-76; 11-21
instrument, 8-131; 11-10
photoelectric, 8-132
telemetering, 8-120, 141
temperature, 8-122, 139; 10-104

Mechanical,
control, 8-55
weighing, 11-40

Medical science, 8-121

Memory,
disk, 11-45
drum, 8-67

Merchandising, 8-82, 132; 9-109

Milling machine 9-69, 109; 10-26
tape controlled, 8-81

Mobility of machines, 9-29

Modular design of electronics, 11-19

Molding machine, 8-131; 9-109; 10-22, 105

Moore, B. P.
Remote Handling with Hydraulics, 9-41

Mounting of machines, 9-33

N

Nucleonics, uses for, 9-106

Numbering code systems,
binary, 8-76; 78; 10-42
combination, 8-78
decimal, 8-78

O

Office Automation, 10-50

Oil refining, 9-17

Orienting, 8-130; 10-35, 104; 11-20

P

Packaging, 8-132; 9-22, 110; 10-26, 32, 35
bottle sealing, 11-23
combination bundler, 8-45
granulated material, 9-24

Paint spraying, 11-44

Pallet loading, 10-35

Peeps, D. J.
Pneumatic Control for Paint Spraying, 11-44

Photocell, 9-69; 11-36

Photoelectric,
control, 8-60; 10-35
measuring, 8-132

Photography, 11-12
developing, 9-108

Pilot, automatic, 8-129

Planning, 8-35, 37, 49, 50, 69, 70; 9-22; 10-18, 47

Plant layout, 8-50, 51; 9-29, 103; 10-46

Plastics, molding machine, 8-131

Plating, tin, 11-109

Playback control, 8-79

Pneumatic
control, 10-34; 11-44, 116
servos, 10-57; 11-49
timer, 11-28
weighing, 9-24; 11-40

Positioning, 11-61

Potentiometer, 10-109

Power,
electrical, 10-17
required for control, 8-80

Presses,
conveyor type, 10-9
handling to, 8-38; 10-49, 52
hydraulic, 10-53

Principles of automatic control, 8-138

Printed circuits, 8-124

Printing, 9-108; 10-26; 11-22
bottle, 9-37
cloth, 11-28

Process design, 8-132

Processing,
continuous, 8-62; 9-47, 64

Product classification,
finished product, 8-70
major component, 8-70
parts to families of models, 8-71

Product design, 8-72; 9-23, 51; 11-18

Production planning, 8-70

Programs, 11-47

Project tinkertoy, 11-19

Proportioning,
batch process, 9-50
ultrasonic, 10-10

Punch press, 11-61

Punched cards, 8-82, 125, 130; 10-9

Punched tape, 10-28

Q

Quantitative control, 8-59

R

Radar, 8-138

Radiation analysis, 9-48

Radioisotope gage, 9-67

Rainey, W.
Electronic Servo Positioning, 11-61

Recording,
camera, 11-14
data, 8-130, 141; 10-28
instrument, 8-129; 9-108
tape, 8-121; 11-12
weight, 9-27; 11-12

Refining, 9-17

Regulating systems, 11-110

Relay,
ceramic, 9-68
telephone, 9-51

Repair, machine, 9-29

Replacement, equipment, 8-150

Resistance, 9-65

Robots, 11-17

Rolling, steel, 11-108

Ross, N. S.
Weight Controlled Volume Filling, 9-24

Rotter, L. C.
Lubricating Automatically, 8-64

S

Safety, 8-80

Savet, P. H.
Computers Can Be Simple, 9-34

Screws, slotting of, 10-44

Sealing bottles, 11-23

Seismology, 8-141

Servo Positioning, 11-61

Servoamplifier, 11-64

Servomechanisms, 11-116
electrical, 8-141; 10-104
hydraulic, 10-57; 11-49
pneumatic, 10-57; 11-49

Shaft, armature manufacture, 10-22

Shaving, gear, 9-46

Shell molding, 9-99

Slotter, 10-44

Social effects, 8-37

Solids,
continuous weighing, 11/39
flow metering, 11-39

Sorting, 8-75, 76, 130; 10-38, 104

Spectra, infrared, 9-47

Spectrometer, mass, 11-46

Spectrometry, 9-67

Speed regulation, 11-112

Spraying, 8-124; 11-44

Stampings, 11-8

Standards, 8-52, 61; 9-65

Steering control, 10-104

Stern, R. K.
Electromechanical Coder, 10-41

Switch, limit, 9-108

Synchros, 8-141

Systems, 11-14

Systems engineering, 11-47

T

Tapes,
control, 8-77, 130; 10-28
data processing, 8-125
packaging, 8-45
punched, 10-28
recording, 8-121; 11-12

Telemetering, 8-120, 141; 11-10

Telephone, answering, 9-108

Television, 11-108

Temperature measurement, 8-122, 139; 10-104

Tension control, 8-58

Terminology,
basic characteristics, 9-65
characteristics of automatic control, 11-59
control system, 9-59
controllers, 8-61
processes, 10-51

Testing,
hardness, 11-10
nondestructive, 10-28
ultrasonic, 10-28

Textile machines, 8-78

Tice, C.
Pushbutton Manufacturing, 10-18

Timers, 8-140; 9-110; 11-28

Tinkertoy project, 11-19

Tool control, 8-51

Tooling, 9-71

Toolometer, 8-52

Traffic control, 8-121

Transducer,
heat transfer, 9-35
self heating, 9-36

Transfer machines, 8-47, 146, 148; 9-101

Transient analysis, 9-112

Transistors, 8-142; 9-113; 10-109; 11-9

Transmission,
data, 10-9
electrical, 10-103

Trucks, lift, 11-58

Tying, 10-32

U

Ultrasonic,
cleaner, 9-72
properties of liquid, 11-116
proportioning, 10-10
testing, 10-28

V

Vehicles, control, 9-108;10-104

Ventilation, 11-116

Vibratory feeders, 8-76

W

Warehousing, 8-60; 9-70, 110; 10-35

Weighing, 8-59; 9-24; 11-12
automatic, 9-50; 11-32, 37
continuous, 9-67; 10-38; 11-39

Weight measurement, 10-102

Welding, 8-127
machine, 10-26

Winding machine, 10-20

Wire-tieing, 10-32

Wrapping, 9-110

AUTOMATION

NEW BOOKS

PRACTICAL DESIGN GUIDE

By R. A. Rinehuls; 132 *pages,* 8½ *by* 11 *inches; published by Pelex Publishers Inc., New York; available from* AUTOMATION, $3.50 *postpaid.*

A reference guide for anyone developing labor saving devices, this book serves as a collection of referral notes, sketches and suggestions. Drawings refer mainly to subjects on pneumatics, electrical control circuits and special feeds.

Material on pneumatics shows how to make applications with air, what valves are available commercially, how they operate and how they are used in practical circuits. Also included, is information pertaining to air applications.

Electrical circuit section shows control circuits which can be combined or modified to serve almost any need. Data on motors, drives and special applications is also given. Sections on indexing, cams and feeds give detailed informatitive material.

♦

SERVOMECHANISMS

By John C. West, lecturer in electrical engineering, University of Manchester; 230 *pages,* 5½ x 7½, *clothbound; published by Macmillan Co., New York; available from* AUTOMATION, $5.00 *postpaid.*

Increased use of automatic control systems in industry, scientific research, and the Armed Forces has made a basic understanding of servomechanisms a necessity for large numbers of engineers in diverse fields. Consequently, this book is written for the undergraduate engineering student and assumes a standard of mathematics about that of a first-year university course and an elementary knowledge of electronics. Subject is developed from examples, and in all cases new ideas are introduced by dealing with a particular case before proceeding to the generalized principles. For this purpose, a simple model is described in the text, and is used as an example throughout the book. Scope includes principles of automatic control and design techniques used in these systems.

♦

FLOW AND FAN

By C. Harold Berry, professor of mechanical engineering, Graduate School of Engineering, Harvard University; 222 *pages,* 5½ x 8½, *clothbound; published by the Industrial Press, New York; available from* AUTOMATION, $4.00 *postpaid.*

Principle of moving air or any gas through ducts or flues is discussed so that elementary and advanced students as well as practicing engineers may have a text and ready reference on the subject. Presentation is based on lecture notes compiled for a course offered at Harvard University to various groups of students in engineering or hygiene fields interested in ventilation either to reduce industrial hazards or promote comfort. Object of the text is to present a statement of the data needed and methods used in finding the aggregate resistance of a system and to help in the practical task of selecting a fan for a given duty.

♦

DIELECTRIC MATERIALS AND APPLICATIONS

Edited by Arthur R. von Hippel, professor of electrophysics and director, Laboratory for Insulation Research, MIT; 425 *pages;* 8½ x 11, *clothbound; co-published by Technology Press of MIT and John Wiley & Sons Inc., New York; available from* AUTOMATION, $17.50 *postpaid.*

Drawing on the knowledge and experience of 22 experts from science and industry, this volume presents an interdisciplinary approach to dielectrics. Edited and unified for maximum usefulness, it provides the scientist and engineer, manufacturer and actual user of dielectrics with fundamental and practical knowledge.

Book opens with a section devoted to theory-establishing a scientific background of language and ideas. Variety of methods and techniques are then described for measuring permittivity and permeability in a frequency range from zero to approximately 3 x 10^{10} cps. Succeeding sections offer a detailed account on dielectric materials and applications together with their properties and limitations.

♦

Government Publications

The Split-Feedback Push-Pull Magnetic Amplifier. *Report PB*113572 *by Office of Naval Research;* 70 *pages; available from Library of Congress, Publication Board Project, Washington* 25, *D. C.;* $3.25 *per microfilm,* $9.00 *per photostat.*

Significant advantages are claimed for a new ac phase-sensitive (push-pull) magnetic amplifier described in this report. Feedback windings in the new circuit are split and arranged so that amplification is high when load current flows and is low when there is no load current. Its principal advantage over the voltage doubler push-pull magnetic amplifier is said to be its low circulating currents which have a maximum rectified average value of one-half the maximum load current.

♦

Materials Suitable for Sound Applications; 1. Ultrasonic Velocities and Impedances of Selected Liquids. *Report* PB 111234 *by Naval Research Laboratory;* 44 *pages; available from Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.;* $1.25.

Designed to aid Navy sonar and laboratory sound research, findings of this investigation include the lowest and highest sound velocities yet reported in any liquid in the normal temperature range. Of special significance is the finding of liquids that more nearly match velocity and impedance characteristics of sea water than any previously used. Results of tests with a number of commercial dielectric liquids and aqueous solutions are presented and the fluids are classified according to their potential use in sound research. Improved instrumentation and equipment developed especially for this study is described.

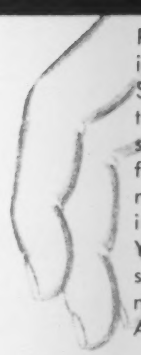
ADVERTISING INDEX

Aetna-Standard Engineering Co., The	16
Allied Radio	113
Allied Steel & Conveyors, Inc., Allied Automation Division	73
Ampex Corporation	81
Baker-Raulang Co., The	2
Barksdale Valves	95
Barnes, W. F. & John, Co., Process Equipment Division	105
Beckman Instruments, Inc., Helipot Corporation Division	113
Bellows Co., The	93
Buschman, E. W., Co., The	91
Chambersburg Engineering Co.	6
Cleveland Tramrail Division, The Cleveland Crane & Engineering Co.	66
Diehl Manufacturing Co., Electrical Division of The Singer Manufacturing Co.	71
Dixon Automatic Tool, Inc.	109
Dynamatic Division, Eaton Manufacturing Co.	83
Eaton Manufacturing Co., Dynamatic Division	83
Electronics Corporation of America, Photoswitch Division	5
Electrol, Inc.	65
Federal Products Corporation	1
Feedall Machine & Engineering Co.	89
Ferguson Machine & Tool Co., Inc.	11, 13
Hamilton Automation, Inc.	111
Hartford Special Machinery Co., The	79
Helipot Corporation, A Division of Beckman Instruments, Inc.	113
Hughes Research & Development Laboratories	75
Hunt, C. B., & Son, Inc.	15
Hydraulic Press Manufacturing Co., The, Hydraulic Power Division	96
James-Pond-Clark	111
May-Fran Engineering, Inc.	84, 85
North American Aviation, Inc.	90
Perry Equipment & Engineering Co.	117
Photoswitch Division of Electronics Corporation of America	5
Pioneer Engineering & Manufacturing Co., Inc.	76
Reliance Electric & Engineering Co.	7
Rivett Lathe & Grinder, Inc.	77
Sola Electric Co.	87
Standard Electrical Tool Co., The	107
Valvair Corporation	Inside Back Cover
Verson Allsteel Press Co.	Back Cover
Wean Equipment Corporation	Inside Front Cover
Engineers Available or Wanted	117

PEECO'S HELPING HAND

small parts FEEDING

INHERENT TO AUTOMATION



PEECO engineered cast bowls scientifically solve small parts feeding problems. Small parts flowing to automatic operations are easily regulated to production speeds with PEECO engineered parts feeders. PEECO single or multi-track engineered bowls safely select, reject, and inspect parts without damage or jamming. You'll like to do business with PEECO. Insist on a PEECO parts feeder—it's engineered. Write for catalog, "Operation—Automation."

Small parts feeding is PEECO'S business—not a side line.

Peeco VIBRATORY PARTS FEEDERS

PERRY EQUIPMENT & ENGINEERING CO.

3125 BRANDES ST., ERIE, PA.

ENGINEERS

AVAILABLE OR WANTED

AUTOMATION ENGINEERS WANTED—Send experience resumes to Research & Development Corp. of America, Corry, Pa.

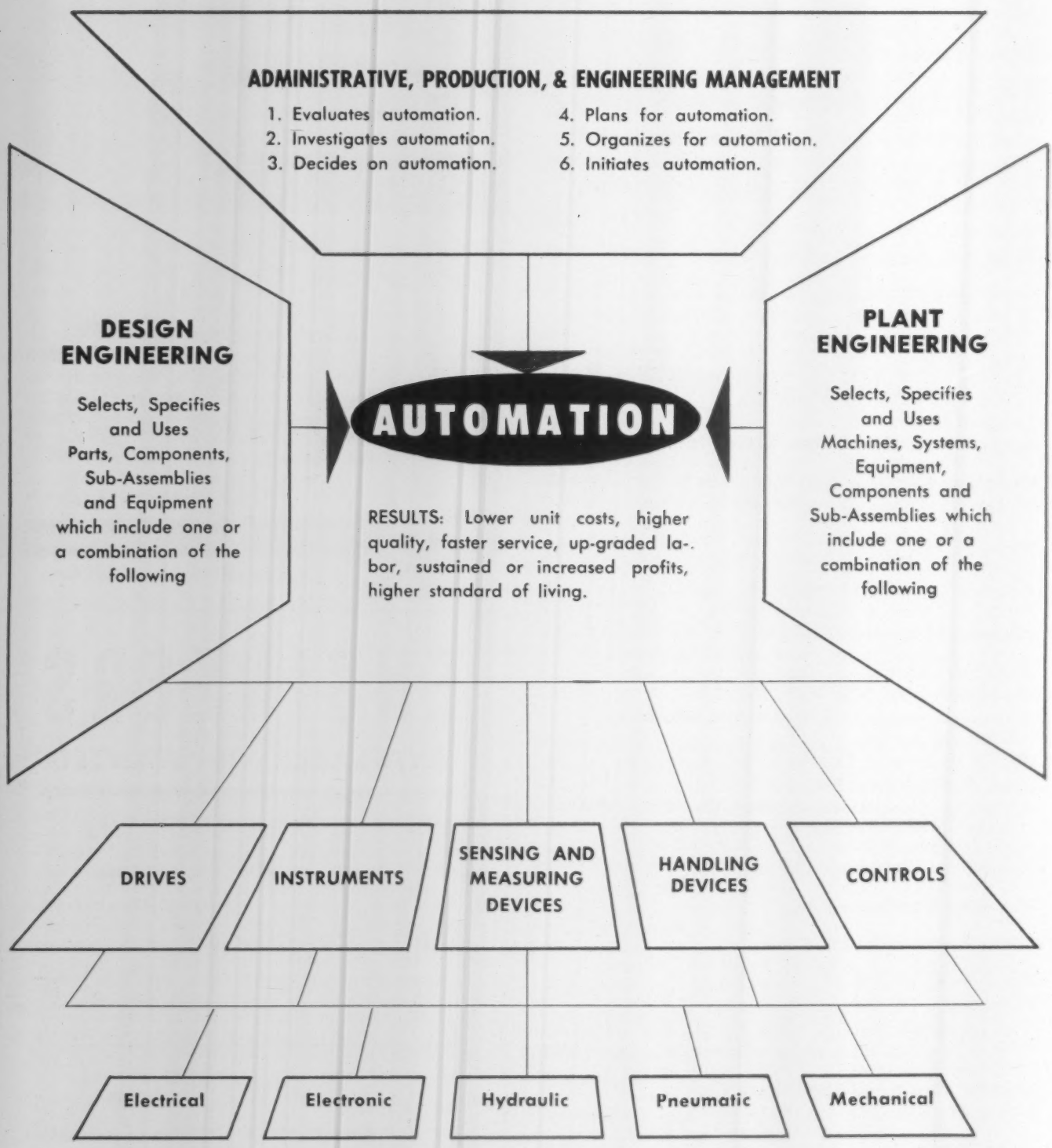
CLASSIFIED RATES

Position Available, per word, per insertion..... .20
Minimum $10.00 (permits 50 words)

Position Wanted, per word, per insertion..... .10
Minimum $3.00 (permits 30 words)

Box number counts as 1 line or 8 words.

INFLUENCES in the ADOPTION of AUTOMATION


ADMINISTRATIVE, PRODUCTION, & ENGINEERING MANAGEMENT
1. Evaluates automation.
2. Investigates automation.
3. Decides on automation.
4. Plans for automation.
5. Organizes for automation.
6. Initiates automation.
DESIGN ENGINEERING
Selects, Specifies and Uses Parts, Components, Sub-Assemblies and Equipment which include one or a combination of the following
AUTOMATION
RESULTS: Lower unit costs, higher quality, faster service, up-graded labor, sustained or increased profits, higher standard of living.
PLANT ENGINEERING
Selects, Specifies and Uses Machines, Systems, Equipment, Components and Sub-Assemblies which include one or a combination of the following
DRIVES
INSTRUMENTS
SENSING AND MEASURING DEVICES
HANDLING DEVICES
CONTROLS
Electrical
Electronic
Hydraulic
Pneumatic
Mechanical

Automation is the science of manufacturing, processing or performing services as automatically as possible within the limits of economic feasibility.

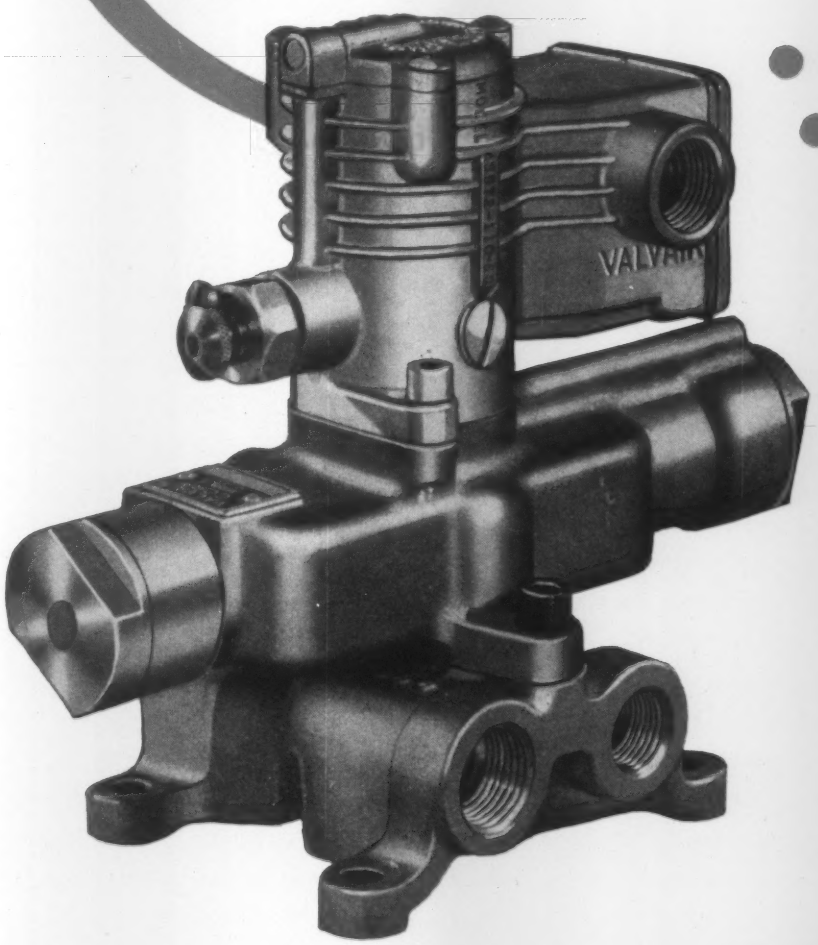
AUTOMATION
A Penton Publication
PENTON BUILDING, CLEVELAND 13, OHIO

SPEED KING

SOLENOID PILOT OPERATED CONTROL VALVE

by VALVAIR

DESIGNED AND BUILT TO J. I. C. STANDARDS



- **A Hefty Assist to Automation**
- **Fully Enclosed**
- **Integral Junction Box**

The Valvair line broadens again — with Speed King's exclusive features. All parts are totally enclosed. The Speed King will operate submerged in water or buried in sand. Simplicity! — only two moving parts. Molded coil — no wear or shorting out. 20,000,000-cycle life and more. Speed King is industry's most rugged and compact valve.

Other features: for pressures from 35 to 200 p.s.i. pneumatics, hydraulics, vacuum; complete line—2-way, 3-way, 4-way and 4-way-5-port (2-pressure) models; foot or sub-base (manifold) mounting; pipe sizes —1/4", 3/8", 1/2", 3/4", and 1".

Ask for Bulletin "A-11"

Representation in: BALTIMORE • BIRMINGHAM • BOSTON
BROOKLYN • BUFFALO • CHARLESTON, W. VA. • CHICAGO
CLEVELAND • CRANFORD, N. J. • DAYTON • DENVER
DETROIT • EUREKA, CALIF. • GLENSIDE, PA. • HOUSTON
KANSAS CITY, MO. • LOGANSPORT, IND. • LOUISVILLE
MILWAUKEE • MINNEAPOLIS • PASADENA • PITTSBURGH
PORTLAND • ST. LOUIS • SAVANNAH • SEATTLE
MONTREAL • TORONTO • VANCOUVER

VALVAIR CORPORATION *Affiliate: Sinclair-Collins Valve Company*
1011 BEARDSLEY AVE., AKRON 11, OHIO

Rely Upon Valvair DIVERSATILITY

THIS Verson TOOL-UP PRODUCES OVER 1000 VALVE COVERS PER HOUR *Automatically*

Consisting of a Verson Transmat Press and Verson Dies, this tool-up is an outstanding example of automatic stamping possibilities where production requirements are high. The press is a 600 ton, 6 station Transmat in which stock is fed from a coil. Five operations on valve covers for overhead valve engines are performed automatically without intermediate handling.

If you mass produce stampings, investigate the economy of Transmat production. For specific recommendations, send an outline of your requirements or write for your copy of the Transmat brochure.

Verson

ORIGINATORS AND PIONEERS OF ALLSTEEL STAMPING PRESS CONSTRUCTION

VERSON ALLSTEEL PRESS CO.

9322 S. KENWOOD AVENUE, CHICAGO 19, ILLINOIS • SO. LAMAR AT LEDBETTER DRIVE, DALLAS, TEXAS

MECHANICAL AND HYDRAULIC PRESSES AND PRESS BRAKES • TRANSMAT PRESSES • TOOLING • DIE CUSHIONS • VERSON-WHEELON HYDRAULIC PRESSES